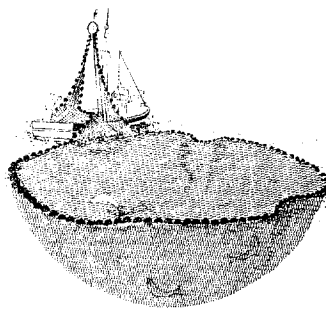
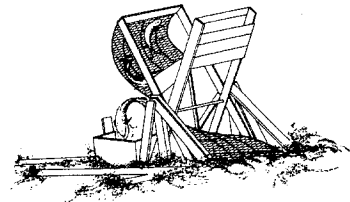
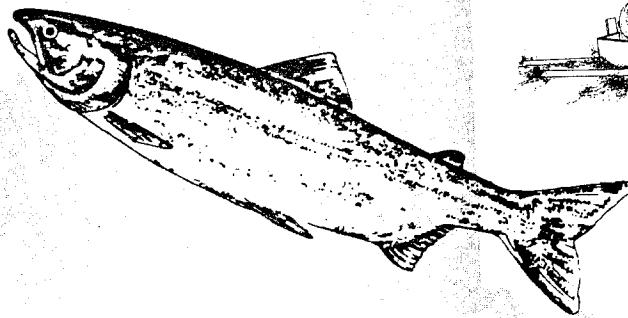
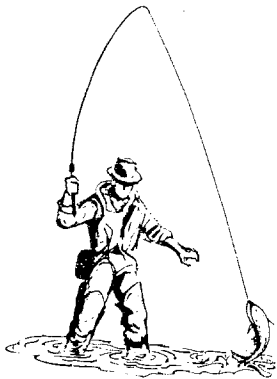
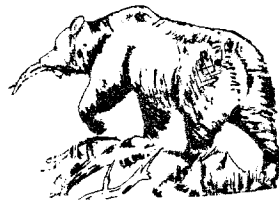


# RUN TIMING AND ABUNDANCE OF ADULT SALMON IN THE TULUKSAK RIVER, YUKON DELTA NATIONAL WILDLIFE REFUGE, ALASKA, 1993

Alaska Fisheries Progress Report Number 95-2



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Region 7

U.S. Fish and Wildlife Service • Department of the Interior

Run Timing and Abundance of Adult Salmon in the  
Tuluksak River, Yukon Delta National Wildlife Refuge, Alaska, 1993

Progress Report

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May 1995

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## Abstract

A resistance board weir was installed on the Tuluksak River for the third season. Detailed run timing, abundance, and biological data were collected for salmon between June 17 and September 10, 1993. The run sizes of 2,218 chinook *Oncorhynchus tshawytscha*, 13,804 chum *O. keta*, and 8,328 coho *O. kisutch* salmon, were the highest numbers recorded for the weir. Peak weekly passages for salmon occurred: chinook, July 4-10; chum and sockeye, July 18-24; pink, July 25-31; and coho, August 29-September 4.

Aerial index surveys have rarely exceeded 5,000 chum salmon and 400 chinook salmon showing their usefulness as only indexes of relative abundance. Salmon stream life above the weir was estimated as: 12 days for chum, 25 days for chinook, 29 days for sockeye, and 6 days for pink salmon. The stream life information and daily passage information indicate that aerial index surveys for chum salmon should be flown several times because of the protracted entrance into the river. Chinook salmon surveys, however, should be flown the last week of July to take advantage of their stream life and relatively fast entrance into the river.

Females made up only 13.9% of the chinook salmon run and were much lower than expected. Subsistence harvest data is needed to determine if that harvest consists of a disproportionate amount of female chinook salmon.

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## Introduction

The Tuluksak River is one of several lower Kuskokwim River tributaries on the Yukon Delta National Wildlife Refuge (Refuge). Located at river kilometer (rkm) 218, the Tuluksak River provides important spawning and rearing habitat for chinook *Oncorhynchus tshawytscha*, chum *O. keta*, sockeye *O. nerka*, pink *O. gorbuscha* and coho *O. kisutch* salmon (Alt 1977; U.S. Fish and Wildlife Service 1992; Harper 1995a). Salmon escapements provide food for brown bears *Ursus arctos* and other carnivores, raptors and scavengers. In addition, resident fish and salmon fry rely heavily on the nutrient base provided by salmon carcasses for growth (U.S. Fish and Wildlife Service 1992). Salmon from Kuskokwim River tributaries also contribute to one of the largest and most intense subsistence salmon fisheries in Alaska. These salmon pass through two commercial fishery districts between the mouth and the Tuluksak River (Francisco et al. 1992; U.S. Fish and Wildlife Service 1988, 1992).

Managing the Kuskokwim River for sustainable harvests requires that individual tributaries receive adequate escapements. Harvest management is complicated by the mixed stock fishery in the lower Kuskokwim River. Harvest level guidelines for the current year are determined from several indices. These include test fishery catch data at Bethel and commercial fishery harvest data in the lower Kuskokwim River from the mouth to the Tuluksak River. Managers attempt to distribute catch through time to avoid overharvesting species and stocks returning to the 11 major and numerous minor tributaries of the Kuskokwim River. Distribution of the catch is necessary since each stock may have a characteristic migratory timing (Mundy 1982). Stocks or species that return in low numbers may be overharvested incidentally during extended harvest periods for abundant stocks. Walters and Cahoon (1985) analysis of British Columbia chinook salmon stocks indicated that since 1950 progressively fewer stocks have made up the majority of the spawning escapement. Data are lacking on many of these individual stocks in the Kuskokwim River drainage and are needed for better management.

The majority of the chinook salmon harvest occurs in the lower Kuskokwim River. This harvest increased from 1985 to 1993 and ranged from 20,670 to 68,018 in the subsistence fishery and from 8,184 to 51,656 in the commercial fishery (Francisco et al. 1993). A conservation concern developed in the mid 1980's when escapements were low. Low escapements were compounded by the low number of chinook salmon females in the escapement. The Alaska Department of Fish and Game (Department) reduced the average yearly commercial harvest of females from 42.8% to 29.3% by reducing gill net mesh size from >20.3 cm to ≤15.2 cm in 1985 (Francisco 1994). The number of gillnet marked female chinook salmon at escapement projects increased after the mesh size change (Doug Molyneaux, Alaska Department of Fish and Game, personal communication). Escapements continued to decline



prompting the Department to eliminate the directed commercial harvest of chinook salmon in 1987. Harvest of surplus fish was reserved for the priority subsistence fishery. These actions have helped to rebuild stocks to the drainage wide escapement objective. Individual stocks of chinook salmon, however, may not reach their escapement objective if there is no monitoring project. Chinook salmon currently harvested in the commercial fishery are taken incidentally during the directed chum salmon openings.

Commercial harvests of chum salmon have exceeded 200,000 every year since 1975. Harvests reached a record of 1,327,006 in 1988 and declined to 326,647 fish in 1992. The 1993 harvest was only 42,718 due to failure of the Aniak River chum salmon stock, restriction of the commercial fishery to only one opening, and the incidental catch during a coho salmon commercial opening. Coho salmon commercial harvests have grown from less than 50,000 fish in the early 1960's to over 450,000 fish most years since 1985. Subsistence users from villages in the lower Kuskokwim River harvested an estimated 20,198 coho salmon and 34,864 chum salmon in 1993. From 1974 to 1992 even year pink salmon commercial harvests have ranged from 16,569 to 85,978.

Chum and chinook salmon abundances in the Tuluksak and other tributary rivers on the Refuge have been estimated using aerial index surveys (aerial surveys) on an opportunistic basis by the Department (Schneiderhan 1983, 1988; Francisco et al. 1992). These aerial surveys are generally conducted after salmon are on the spawning grounds. Weather delays and poor visibility make some aerial surveys of questionable value. These counts underestimate escapements even during optimal conditions. Aerial surveys do not gather age, sex, and size composition data, which are used to determine escapement quality. The timeliness of these aerial surveys usually gives only an index of how many fish made it to the spawning grounds. They are usually conducted too late to make management decisions, which allow more fish to reach the spawning grounds and meet escapement objectives. The Refuge has supported these aerial surveys in recent years with aircraft and pilots because they represent the only available data for several tributaries. Information to determine optimal aerial survey timing for Refuge rivers has not been collected.

Chinook and chum salmon aerial index counts on the Tuluksak River have been below 50% of the aerial index objective for most years (Appendix 1). Coho salmon escapement objectives have not been set for rivers on the Refuge because few data have been collected. Because coho salmon are important to the commercial and subsistence fisheries, additional biological data should be gathered to help maintain sustainable populations.

The Department has gathered limited fishery data on lower Kuskokwim River drainages on the Refuge. In 1978, a sonar project was tried on

the Kwethluk River but was dropped after high debris loads gave false readings (Schneiderhan 1979).

The Department currently operates two salmon escapement projects, the Aniak River sonar located above the refuge boundary and the Kogruklu River weir located on the Holitna River drainage (Figure 1). Both projects are located above the commercial fishery at approximately 378 and 781 rkm from the mouth of the Kuskokwim River. Spawning escapement counts, from the Aniak River sonar and the Kogruklu River weir, are used to make management decisions, which affect escapements into all Kuskokwim River tributaries, including those on the Refuge.

The salmon populations found in the Kuskokwim River drainage are currently heavily exploited. The Alaska National Interest Lands Conservation Act mandates that, within the Refuge, salmon populations and their habitats be conserved. Because the human population of the region is expected to increase, conserving individual fish populations so they continue to provide for subsistence and commercial harvest allocations will require better escapement data. The Refuge Fishery Management Plan identifies the lack of adequate escapement data as a problem. Salmon escapement studies for lower Kuskokwim River tributaries on the Refuge are ranked as priority projects by the U.S. Fish and Wildlife Service (Service) and the Department (U.S. Fish and Wildlife Service 1992).

In 1991, a multi-year study was initiated by the Service to: (1) estimate daily salmon escapements in the Tuluksak River; (2) quantify the salmon age, sex, and length composition; (3) estimate migration rates between the test fishery and the weir; (4) estimate optimal timing to gather aerial survey data; (5) monitor gill net marks; and (6) count other species passing through the weir.

### Study Area

The Tuluksak River is located in the lower Kuskokwim River drainage (Figures 1, 2). The region has a subarctic climate characterized by extreme temperatures. Summer temperatures average a high of 15°C and average winter lows are near -12°C (Alt 1977). Average yearly precipitation is about 50 cm, and the majority falls between June and October. River break-up occurs in early May and freeze-up occurs in late November.

The Tuluksak River originates in the Kilbuck Mountains, flows northwest approximately 137 km, and drains an area of about 2,098 km<sup>2</sup>. The Fog River is the only major tributary to the Tuluksak River, and enters the lower section. The Tuluksak River is a slow moving, meandering stream over most of its length, cutting through several tundra areas in its lower section (Alt 1977). Gravel bottoms, cut banks and overhanging vegetation predominate in the

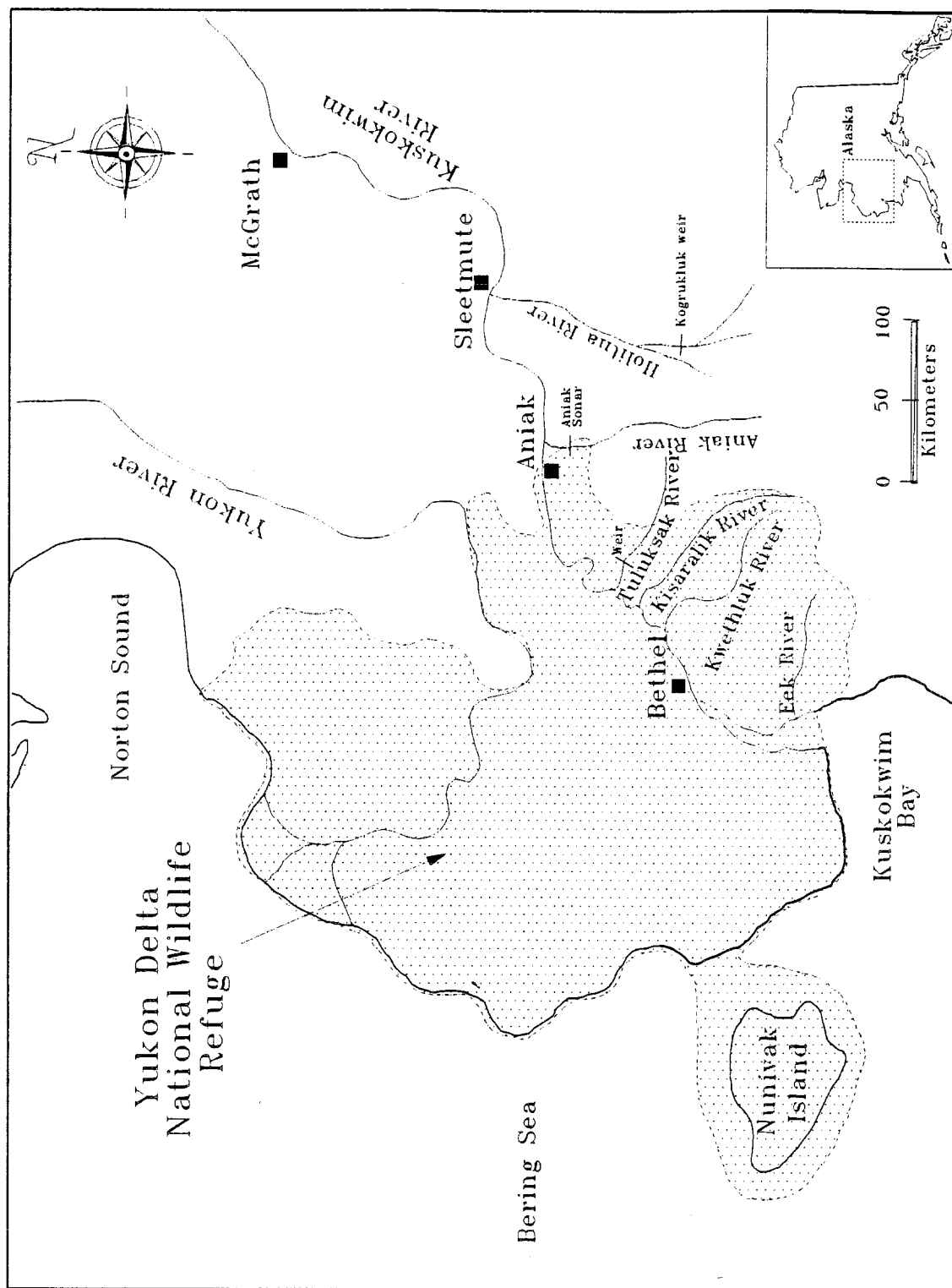


FIGURE 1.—Lower Kuskokwim River tributaries on the Yukon Delta National Wildlife Refuge, Alaska, 1993.

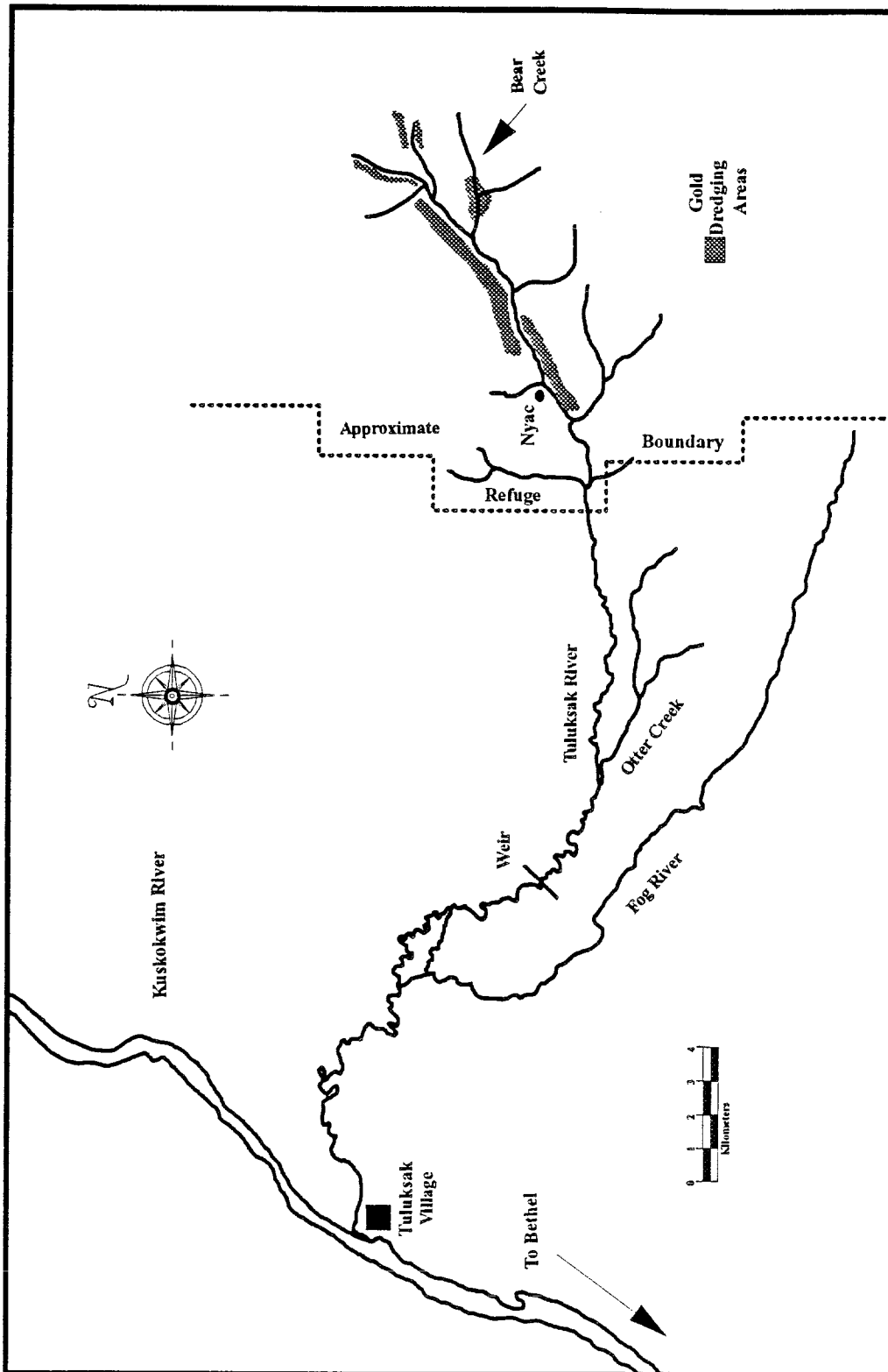


FIGURE 2.—Fish weir location on the Tuluksak River, Alaska, 1993.

upper section of the river. Water clarity in the upper section is 1-2 m during low water. The lower section is characterized by generally turbid waters flowing through deep mud lined channels.

Gold dredging near the mining camp of Nyac (Figure 2) since the early 1900's has extensively changed the upper drainage above the Refuge boundary (Crayton 1990; Francisco and Sundberg 1983). Dredging activity is currently confined to Bear Creek, a tributary to the Tuluksak River above the Refuge boundary, but may be expanded.

## Methods

### *Weir Operation*

A resistance board weir (Tobin 1994) with picket spacing of 3.5 cm spanning 48 meters of river was installed for a third year at rkm 76 (N 60°, 59', 160° 33' W) in the Tuluksak River. The weir was operational from June 17 to September 10, 1993. A staff gauge was installed on the back side of the bulkhead and daily water levels were recorded at 0800 h each day. Stream discharge was estimated using the method described by Hamilton and Bergersen (1984) with a Marsh-McBirney (Model 201-D) flow meter and top setting wading rod. Water temperatures were measured once during the middle of the day.

All fish were identified to species and counted as they passed through the weir. The trap was usually opened at 0700 hours and closed at midnight or earlier depending on the length of daylight. The weir was checked for holes and weakness and cleaned daily before 0900 hours. Snorkeling was used to check weir integrity and substrate conditions. Cleaning consisted of walking across each panel until it was partially submerged allowing the current to wash debris downstream. Algal growths were removed by scrubbing with long handled brooms. Spent salmon and carcasses (carcasses) washed up on the weir were counted daily by species and passed downstream at four hour periods when panels were cleaned.

### *Biological Data*

Sample weeks or strata started on Sunday and ended the following Saturday. A weekly quota of 160 chum, 140 chinook and 140 coho salmon was collected at the beginning of each week. Samples were collected in as short a period (1-3 days) as possible to approximate a pulse or snapshot sample (Geiger et al. 1990). When fish were sampled, the trap was allowed to fill with fish. All fish within the trap were sampled to prevent bias. Pink salmon were randomly sampled throughout the season to obtain a 40 fish sample. Once weekly quotas were obtained, the trap was opened during the day and fish passed until the next sample period.

Sampled fish were measured, scales collected for aging, identified to sex using external characteristics, and released upstream. Salmon were measured to the nearest 5 mm mid-eye to fork length. Gill net marks were noted for each species. Scales were removed from the preferred area for age determination (Koo 1962, Mosher 1968). Scale impressions were made on cellulose acetate cards using a heated scale press and examined using a microfiche reader. Salmon ages were reported using the European Method (Koo 1962).

All salmon were aged by the Department biologist who aged the commercial catch samples. Ages were verified by another Department biologist who compared scales to known ages of coded wire samples from other areas. Age data were compiled by the Department.

Age and sex composition of the weekly weir passage were estimated using a stratified sampling design (Cochran 1977). Strata were pooled if sufficient samples were not obtained in a single stratum. Age composition and associated variances for weekly passage were calculated as:

$$\hat{A}_h = N_h p_h; \quad (1)$$

$$\hat{V}[\hat{A}_h] = N_h^2 \left( \frac{p_h(1-p_h)}{n_h-1} \right); \quad (2)$$

$\hat{A}_h$  = the estimated number of fish of a given age and sex during week  $h$ ,

$N_h$  = the number of fish passing in week  $h$ ,

$p_h$  = the proportion of sample in week  $h$  of a given age.

Weekly abundance estimates and their variances were summed to obtain age and sex composition estimates for the season as follows:

$$\hat{A}_{st} = \sum \hat{A}_h; \quad (3)$$

$$\hat{V}[\hat{A}_{st}] = \sum \hat{V}(\hat{A}_h); \quad (4)$$

where:

$\hat{A}_{st}$  = the estimated number of fish of a given age for the season.

A z-test comparing the proportion of one sexes age to another was used to determine if age composition differed between the sexes.

Proportions within each sex for a given age was calculated as:

$$\hat{p}_{ij} = \frac{\hat{A}_{st,ij}}{\hat{A}_{st,i}}; \quad (5)$$

where:

$i$  = sex,

$j$  = age,

$\hat{A}_{st,ij}$  = estimated number of fish of sex  $i$  and age  $j$ , and

$\hat{A}_{st,i}$  = estimated number of fish of sex  $i$ .

The variance was calculated as:

$$\hat{V}(\hat{p}_{ij}) = \hat{p}_{ij}^2 \left[ \frac{\hat{V}(\hat{A}_{st,ij})}{\hat{A}_{st,ij}^2} + \frac{\hat{V}(\hat{A}_{st,i})}{\hat{A}_{st,i}^2} \right]; \quad (6)$$

where the variances are the variances calculated per equation (4).

The proportions were considered different if  $z$  was greater than the critical value from a Z-table.  $z$  was calculated as:

$$z = \frac{\hat{p}_{ij} - \hat{p}_{i'j}}{\sqrt{\hat{V}(\hat{p}_{ij}) + \hat{V}(\hat{p}_{i'j})}}; \quad (7)$$

where:

$i'$  = the other sex.

The sample size was assumed to be large enough to use the Z-distribution. Applying the Bonferroni adjustment,  $p$  was significant at the  $\alpha=0.05$  level if  $p < 0.05/k$ , where  $k$  was the number of age groups.

#### Migration Rates

Several methods were used to estimate the migration time in days for salmon to travel the 169 km between the test fishery and the weir. The time in days was estimated as the difference between the dates when 50% of the cumulative run passage occurred at each location. Fish bound for the Tuluksak River were assumed to be equally represented in test fishery sampling and not temporally separated.

Stream life (the amount of time each salmon species remained above the weir) was similarly estimated. Stream life was assumed to be the difference between the dates when 50% of the cumulative upstream

migration and the downstream passage of carcasses occurred. Data on stream life were used to estimate optimal timing for aerial surveys.

## Results

### Weir Operation

The weir was fish tight on June 17, 1993, and all fish were passed through the trap. The trap and chute were located in deep water (>70 cm) throughout the operation. A hole developed under the weir on the night of August 1 and was sealed on August 2. Some uncounted fish may have passed upstream that night. The weir was never submerged due to high water levels during the operation period and temperatures rarely exceeded 12°C (Appendix 2). Discharge was measured on June 24 at 14.66 m<sup>3</sup>/s and again July 26 at 6.95 m<sup>3</sup>/s.

### Biological Data

A total of 13,804 chum, 2,218 chinook, 88 sockeye, 210 pink, and 8,328 coho salmon were counted through the weir between June 17 and September 10, 1993 (Figure 3, Appendix 3 & 4). Salmon carcasses passed downstream over the weir consisted of 4,678 chum, 548 chinook, 27 sockeye, 140 pink and 2 coho salmon (Appendix 5). Other species passing through the weir included 502 Dolly Varden *Salvelinus malma*, 642 whitefish (*Coregonus pidschian*, *C. nasus*, *C. autumnalis* and *Prosopium cylindraceum*), 75 Arctic grayling *Thymallus arcticus*, and 6 northern pike *Esox lucius* (Figure 4 and Appendix 3).

*Chum salmon.*—Chum salmon ( $N=13,804$ ) was the first salmon species counted, passing through the weir on June 18. Peak passage ( $N=3,722$ ) occurred the week of July 18-24 (Figure 3). Fifty percent of the migration passed the weir by July 19, 29 days after the first chum salmon passed through the weir (Figure 5, Appendix 6).

Scale samples of 1,163 chum salmon from the escapement were useable and aged. The passage was composed of 50.1% females, and 49.9% males distributed among four age classes, 0.2, 0.3, 0.4 and 0.5 (Table 1, Appendix 7).

Age composition of males and females differed (Appendix 7, Bonferroni adjustment  $\alpha=0.0125$ ). Age 0.4 fish composed 56.5% of the chum salmon run and was predominately males, and age 0.3 composed 36.4% of the run and was predominately females. Age 0.4 chum salmon predominated in the weekly passage until the week of July 25-31, when age 0.3 fish predominated (Appendix 7). The mean lengths of males were longer than females in age groups 0.3, 0.4, and 0.5 (two tailed t-test: age 0.3,  $t=10.97$ ,  $df=427$ ,  $p<0.001$ ; age 0.4,  $t=16.22$ ,  $df=616$ ,  $p<0.001$ ; age 0.5,  $t=6.58$ ,  $df=83$ ,  $p<0.001$ ). Females initially made up less than 24% of the run, but predominated after the July 18-24 sample (Figure 6, Appendix 7). Gill net marks ( $N=172$ ) were seen on 1% of the chum salmon passing the weir (Appendix 3).



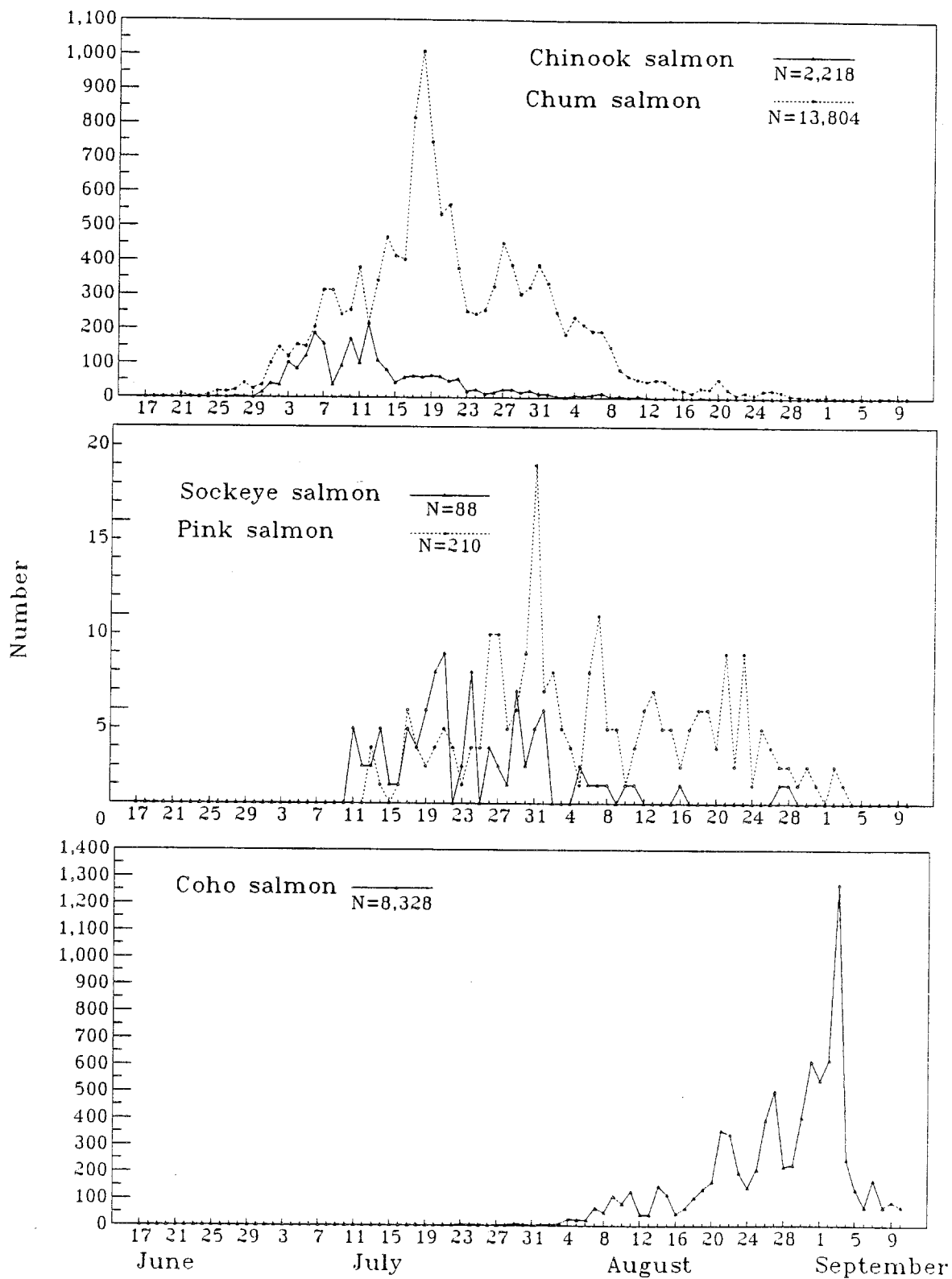


FIGURE 3.—Salmon counted through the Tuluksak River weir, Alaska, June 17 to September 10, 1993 (note different Y-axis scales).

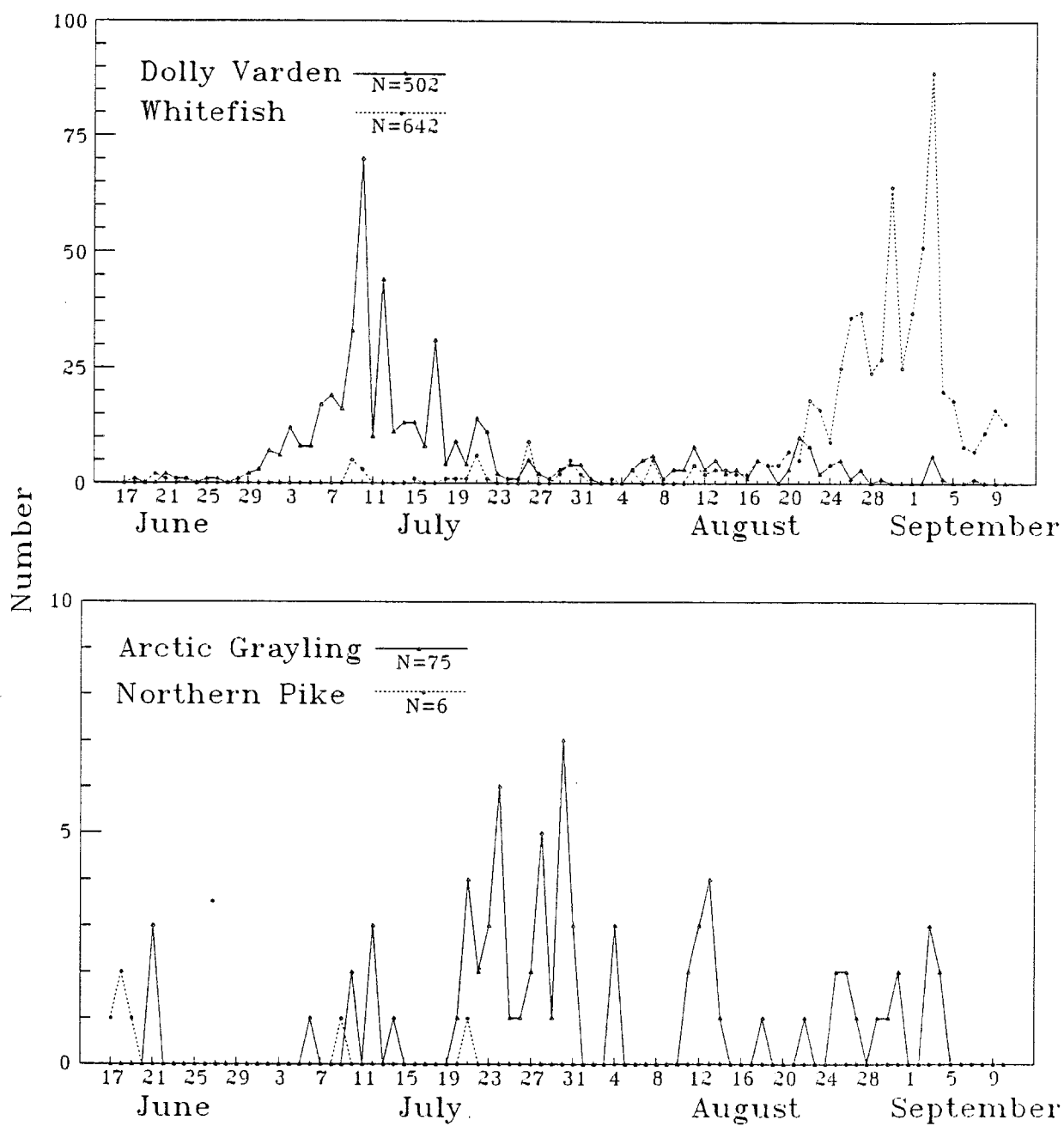


FIGURE 4.-Resident fish counted through the Tuluksak River weir, Alaska, June 17 to September 10, 1993 (note different Y-axis scales).

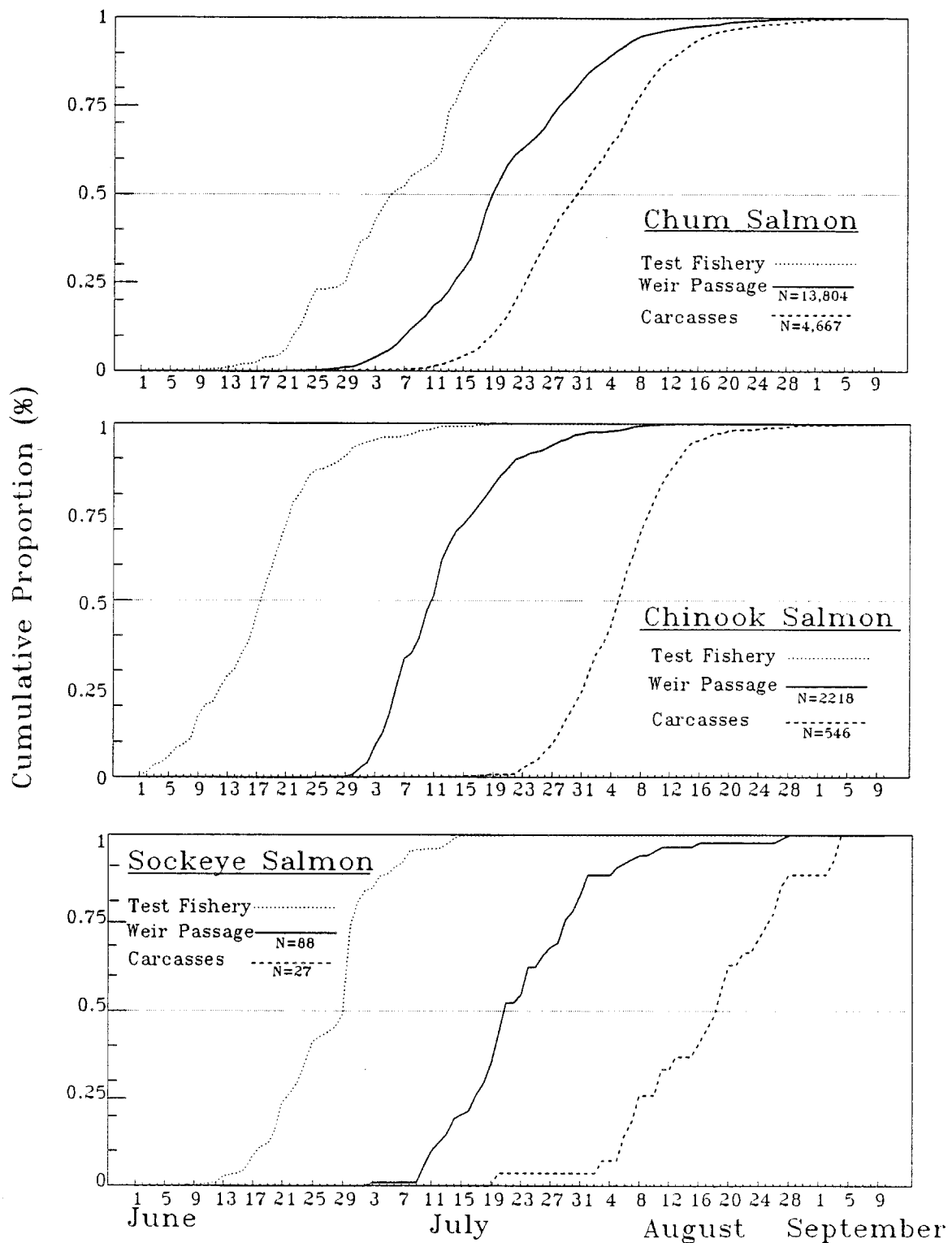


FIGURE 5.-Comparison of Bethel test fishery cumulative salmon catch per unit effort and upstream passage and salmon spawnouts and fish carcasses passed downstream, at the Tuluksak River weir, Alaska, 1993.

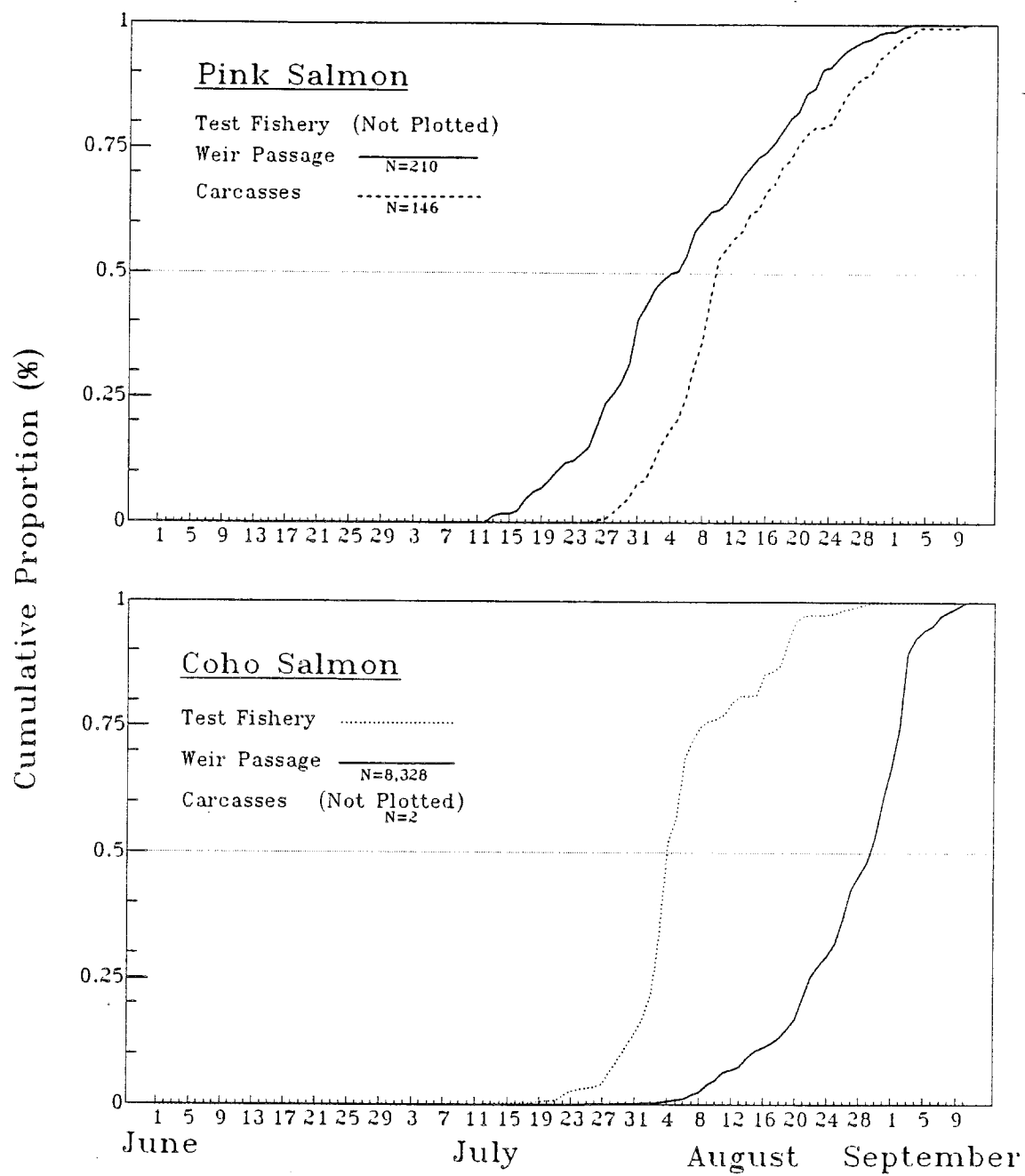


FIGURE 5.-(Continued).

TABLE 1.-Age and length (mid-eye to fork length) composition of chum salmon sampled at the Tuluksak River weir, 1993.

Age	N	Length (mm)		
		Mean	SE	Range
Female				
0.2	28	483	5.71	430-560
0.3	274	514	1.85	445-615
0.4	281	530	1.85	425-610
0.5	28	547	5.77	485-620
Total	611	522	1.34	425-620
Male				
0.2	3	490	12.58	475-515
0.3	155	548	2.51	460-625
0.4	337	571	1.65	480-680
0.5	57	591	3.81	525-650
Total	552	566	1.43	460-680

Chum salmon carcasses ( $N=4,678$ ) were first observed on June 28, seven days after fish first passed the weir (Figure 5). Fifty percent of the carcasses were passed downstream by July 31, 33 days after the first carcass was passed downstream and 12 days after 50% of the upstream migration had occurred.

*Chinook salmon.*-Chinook salmon ( $N=2,218$ ) were first passed on June 26, four days after the first chum salmon (Figure 5). Peak passage ( $N=849$ ) occurred the week of July 4-10 (Figure 3). Fifty percent of the migration passed the weir by July 11, 16 days after the first fish passed.

Scale samples of 618 chinook salmon from the escapement were useable and aged. The escapement was composed of 86.1% males and 13.9% females distributed among eight age groups (Table 2).

Age composition of males and females differed (Appendix 8, Bonferroni adjustment  $\alpha=0.006$ ). Males in age groups 1.2 and 1.3 were estimated to compose 51.4% and 26.1% of the escapement (Appendix 8). The majority of the females were in age groups 1.4 and 1.3 and made up only 10.5% and 2.1% of the total passage. Only males were found with two years of freshwater growth accounting for 1.8% of the passage. Age composition of male and female chinook salmon differed (Appendix 8, Bonferroni adjustment  $\alpha=0.005$ ).

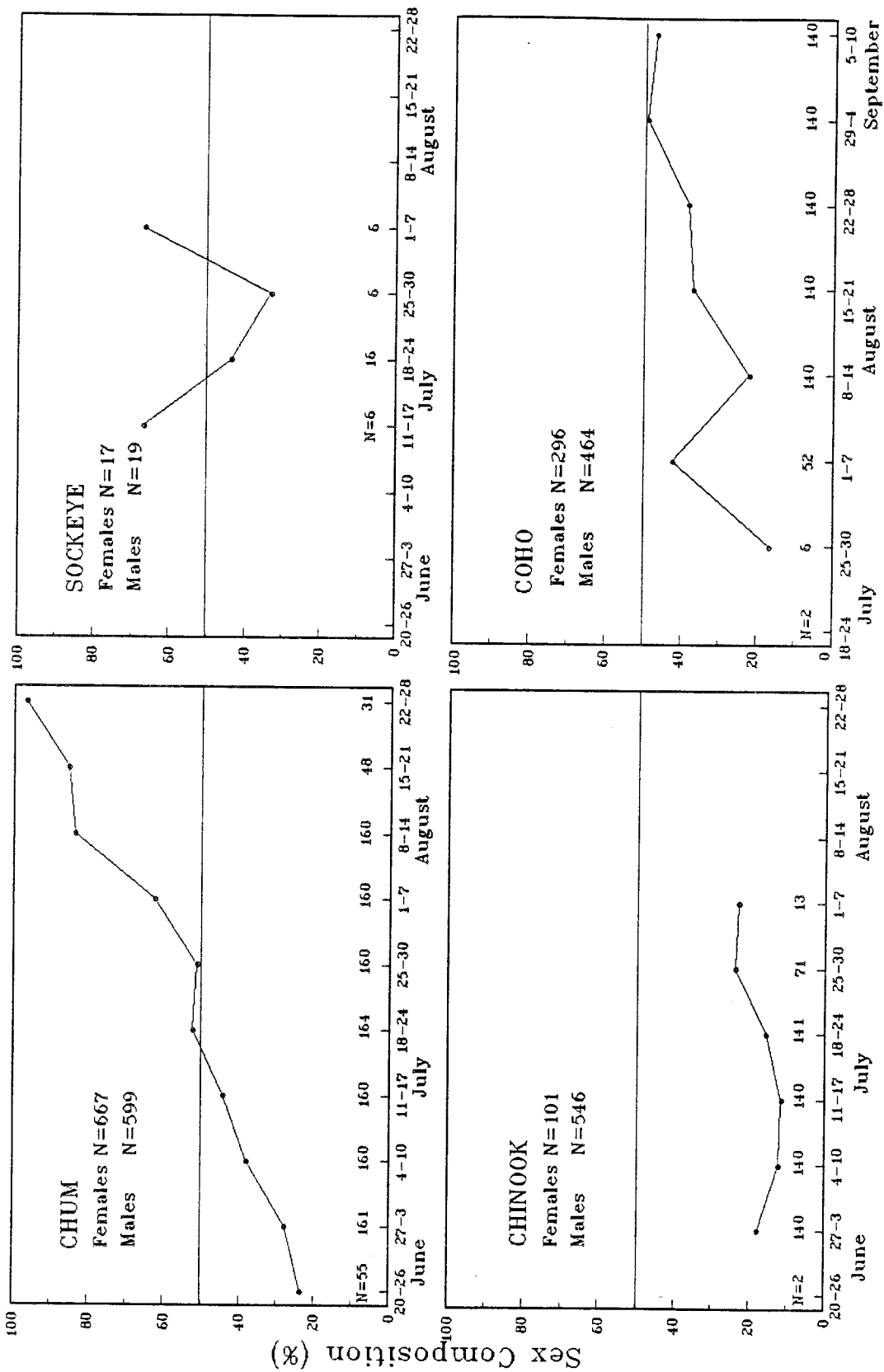


FIGURE 6.—Weekly sex composition (expressed in % females) of salmon sampled at the Tuluksak River weir, Alaska, 1993.

TABLE 2.-Age and length (mid-eye to fork length) composition of chinook salmon sampled at the Tuluksak River weir, Alaska, 1993.

Age	N	Length (mm)		
		Mean	SE	Range
Female				
1.2	6	541	13.81	475 - 565
1.3	12	811	8.31	775 - 865
1.4	73	871	5.91	730-1,010
1.5	4	915	36.11	815 - 975
Total	95	844	9.76	475-1,010
Male				
1.1	7	389	11.99	330 - 415
1.2	313	537	3.31	335 - 690
1.3	154	675	6.62	405 - 895
1.4	38	810	14.41	665 - 970
1.5	1	725	-	-
2.2	2	585	30.00	555 - 615
2.3	6	695	22.82	640 - 785
2.4	2	708	87.50	670 - 795
Total	523	598	4.93	330 - 970

The mean lengths of females were longer than males in ages 1.3, and 1.4 (two tailed t-test: age 1.3;  $t=5.7$ ,  $df=167$ ,  $p<0.001$ ; age 1.4,  $t=4.61$ ,  $df=109$ ,  $p<0.001$ ). Lengths were similar between sexes for age group 1.2 (two tailed t-test,  $t=0.166$ ,  $df=317$ ,  $p=0.869$ ). Insufficient data were available for comparison of other ages.

Sex composition changed weekly on all species of salmon (Figure 6). Females composed less than 24% of the chinook salmon sampled each week, and dropped to a low of 11% the week of July 4-11.

Gill net marks were observed throughout the season and were observed on 4% ( $N=84$ ) of the chinook salmon passing the weir (Appendix 3). The number of gill net marks on females (14%) differed from the number found on males (5%) ( $\chi^2=13.41$ ,  $df=1$ ,  $p<0.001$ ).

Chinook salmon carcasses ( $N=548$ ) were first observed on the weir July 3, 8 days after the first chinook salmon was passed upstream (Figure 5). The next carcass was seen on July 15 and fifty percent had passed downstream by August 5. This was 33 days after the first

chinook salmon was passed downstream and 25 days after 50% of the upstream migration had occurred.

*Pink salmon.*—Pink salmon ( $N=210$ ) started to pass the weir on July 13 and continued until September 3 (Figure 3). Peak passage ( $N=56$ ) was the week of July 25-31. Fifty percent of the migration had passed by August 4, or 22 days after passage of the first pink salmon (Figure 5).

Forty-one pink salmon were measured and sexed. Lengths ranged from 360 to 495 mm. Females ( $N=13$ ) averaged 414 mm and males ( $N=28$ ) averaged 413 mm. Gill net marks were seen on only one pink salmon passing the weir.

Pink salmon carcasses ( $N=140$ ) were passed downstream starting July 26. Fifty percent were passed downstream by August 10. This was 15 days after the first fish was passed downstream and six days after 50% of the upstream migration had occurred (Figure 5).

*Sockeye salmon.*—Sockeye salmon ( $N=88$ ) passed the weir starting July 3 and continued until August 28 (Figure 3). Peak passage ( $N=32$ ) was the week of July 18-24. Fifty percent of the migration had passed by July 21, which was 18 days after the first sockeye salmon passed upstream (Figure 5, Appendix 5).

Sockeye salmon escapement was estimated to be composed of 48.5% females and 51.5% males distributed among five ages (Table 3, Appendix 9). Dominant age classes were 1.3 (54.5%) and age 1.2 (24.2%). Sex composition varied widely by week (Figure 6).

Mean lengths of males were longer than females for age 1.3 (two tailed  $t$ -test,  $t=3.58$ ,  $df=16$ ,  $p<0.002$ ). Female percentages varied by sample period (Figure 6). Gill net marks ( $N=1$ ) were seen on 1% of the sockeye salmon passing the weir.

A total of 27 sockeye salmon carcasses were passed downstream over the weir (Figure 5). Fifty percent of the carcass passage occurred by August 19, 30 days after the first one was passed downstream, and 29 days after 50% of the upstream migration had occurred.

*Coho salmon.*—Coho salmon ( $N=8,328$ ) passed the weir starting July 23. Peak passage occurred the week of August 29-September 4, when 3,936 were passed (Figure 3). The second highest peak occurred August 22-28 with a passage of 2,016. Daily coho salmon passage was still 71 fish the day before the weir was removed. Fifty percent of the migration passed by August 30, 36 days after the first coho salmon was passed (Figure 5).

Scale samples from 669 coho salmon were useable and aged. The passage was composed of 43.1% females and 56.9% males distributed among 5 age classes, 1.1, 2.1, 2.2, 3.1, and 3.2 (Table 4, Appendix 10). Age composition differed between sexes (Appendix 10, Bonferroni



adjustment  $\alpha=0.0125$ ). Age 2.1 fish dominated the five age groups (83.0%). Males (46.4%) and females (36.6%) in this age class composed the majority of the run.

TABLE 3.-Age and length (mid-eye to fork length) composition of sockeye salmon sampled at the Tuluksak River weir, Alaska, 1993.

Age	N	Length (mm)		
		Mean	SE	Range
Female				
0.3	2	560	10.00	550-570
1.2	3	538	14.24	510-555
1.3	9	524	9.48	485-580
2.3	2	535	5.30	530-540
Total	16	512	22.98	355-615
Male				
0.2	1	420	-	-
0.3	2	478	122.50	355-600
1.2	5	433	37.44	370-575
1.3	9	575	10.44	510-615
Total	17	512	22.98	355-615

Mean lengths of females were longer than males for ages 2.1 and 2.2 (two tailed t-test: age 2.1,  $t=6.04$ ,  $df=587$ ,  $p=0.016$ ; age 2.2,  $t=2.536$ ,  $df=37$ ,  $p=0.016$ ) and did not differ for age 3.1 ( $t=0.86$ ,  $df=29$ ,  $p=0.397$ ). Insufficient sample sizes were available to test the other age classes. Females (43.1%) made up a significantly lower percentage than males ( $\chi^2=89.49$ ,  $df=4$ ,  $p<0.001$ ). Females made up less than 50% of the weekly samples. The lowest percentage (21%) occurred the week of August 8-14 (Figure 6, Appendix 10).

Gill net marks ( $N=385$ ) were found on 5% of the coho salmon counted. Only 2 coho salmon carcasses were passed downstream over the weir and stream life above the weir was not estimated.

TABLE 4.--Age and length (mid-eye to fork length) composition of coho salmon sampled at the Tuluksak River weir, Alaska, 1993.

Age	N	Length (mm)		
		Mean	SE	Range
Female				
1.1	1	450	-	-
2.1	231	542	2.51	430-655
3.1	8	535	12.03	400-595
2.2	18	552	6.84	485-590
3.2	1	545	-	-
Total	259	542	2.34	430-655
Male				
1.1	7	524	26.24	435-595
2.1	358	517	2.92	395-635
2.2	21	507	15.26	415-615
3.1	23	513	14.34	405-625
3.2	1	-	-	-
Total	410	517	2.80	355-635

#### *Migration Rates*

The difference between the 50% passage dates at the test fishery and at the weir for salmon was: 13 days for chum, 23 days for chinook, 21 days for sockeye, and 26 days for coho. Pink salmon data were not plotted (Figure 5). Using the day when 50% of the salmon had passed both the test fishery and the weir, salmon swimming speeds in km/d were: 13 for chum, 7 for chinook, 8 for sockeye, and 6.5 for coho salmon.

The run timing for 90% of each salmon species to pass the weir varied as follows: 45 days for chum, 27 days for chinook, 41 days for pink, 33 days for sockeye, and 41 days for coho salmon.

#### **Discussion**

The spacing between pickets (3.5 cm) may have allowed smaller fish to pass through undetected. Some resident fish that were in the trap moved freely through the pickets when an attempt was made to net them. Smaller pink salmon may also have passed through the pickets undetected, although none were seen. Identification of whitefish to

species was difficult and most were only classified as whitefish. Capture and individual examination would have been necessary for species identification.

The hole that developed under the weir during the evening of August 1, was small and did not appear to affect salmon counts. Daily numbers of salmon decreased before the hole developed and continued to decline after repairs were made. The exception was sockeye salmon that did not pass the weir again for several days. Numbers of sockeye salmon, however, were small throughout the season similar to numbers found in 1991 and 1992 (Harper 1995a; Harper 1995b).

The count data from this project do not include salmon returning to the Fog River or several small tributaries located below the weir. Because the proportion of females in the escapement is important for chinook salmon production, a monitoring facility like a weir is needed to gather that type of data.

#### *Biological Data*

*Chum salmon.*—The 1993 run of chum salmon ( $N=13,804$ ) was 23% larger than the 1992 run ( $N=11,183$ ), and 80% larger than the 1991 return of 7,675 (Harper 1995a; Harper 1995b). A larger return of chum salmon was probably the result of several factors. First, the Aniak River, a major chum salmon producer in the Kuskokwim River drainage, was experiencing a weak return. As a conservation measure, fewer commercial openings were allowed in the lower Kuskokwim River (Francisco et al. 1994). Second, the environmental factors that affected the Aniak River chum salmon run did not appear to alter the Tuluksak River run.

Chum salmon returning in late August and early September appeared to consist of a number of small bright fish. These chum salmon were smaller and did not possess the mottling color characteristic of most chum salmon passing the weir. They may have been composed of age 0.2 fish that show up at the tail of the run and are substantially smaller than the age 0.3 chum salmon. These fish are also reported from other escapement projects on the Kuskokwim River (Kim Francisco, Alaska Department of Fish and Game, Division of Commercial Fisheries, personal communication).

*Chinook salmon.*—The 1993 run of chinook salmon ( $N=2,218$ ) was larger than the 1992 run of 1,083 or the 1991 run of 697 (Harper 1995a; Harper 1995b). The percentage of females in the run (13.9%) was lower than the 14.8% return in 1992 or the 28.8% in 1991. The percentage of females in the 1993 Kuskokwim River commercial catch (6.3%) was below the Tuluksak River weir samples and the 1985-1993 average returns (32.7%) to the Kogrukluk River weir (Department files). Commercial catch data from 1993 is limited and based upon only two commercial openings. Only 307 female chinook salmon were estimated in the 1993 return. This number was higher than the

estimated 201 in 1991 and 160 in 1992. When chinook salmon pass the weir, the potential to misidentify the sex is low because, fish are bright red, sexually mature, and males have developed a pronounced kype.

The low percentage of females returning to the Tuluksak River raises some concern and may be due to several factors. Females return at older ages than males and incur additional years of ocean mortality (Hankin and Healy 1986). The subsistence fishery may also harvest a larger proportion of the females in the run. This fishery allows nets with larger mesh sizes than the commercial fishery. These larger mesh nets selectively target the larger fish, including older female chinook salmon that predominate the larger sizes (Francisco et al. 1991). Fewer fish and fewer female chinook salmon would reach the Tuluksak River if intensive fishing effort coincided with the run timing of this stock. Walters and Cahoon (1985) have found as fishing has intensified in British Columbia waters, some chinook salmon populations now only persist as remnants. These remnant populations contribute little to the overall spawning populations and the commercial fisheries.

The percentage of gill net marked female chinook salmon in 1993 (14%), was higher than in 1991 (9.9%), and lower than the 20.6% in 1992 (Harper 1995a; Harper 1995b). It was also lower than the 1986-93 average (17.9%) found at the Kogrukluk River weir, and lower than the 11.3% in 1993 found at that location (Department files). The restriction of the commercial fishery to smaller mesh nets has allowed some larger females to drop out of nets and continue their migration. The lower percentage of gill net marked females in the Tuluksak River may be the result of a higher percentage of the larger females being harvested by the subsistence fishery before reaching the Tuluksak River weir. Data on the sex ratio of subsistence catches from the Tuluksak River are not available for confirmation.

The high percentage of gillnet marks found during a year when only two commercial openings were allowed indicates that the Tuluksak River stock of chinook salmon was probably within the commercial district at the time of the openings. In addition, there may have been a large number of drop outs from the subsistence fishery.

*Pink salmon.*-Kuskokwim River pink salmon have strong even year runs (Francisco et al. 1992). Commercial catches in the Kuskokwim River have averaged 3,948 for even years and 217 for odd years since 1980 (Francisco et al. 1992). The 1993 count of pink salmon was small because larger returns only occur in even years. No escapement goals have been established for pink salmon in the Kuskokwim River drainage.

*Sockeye salmon.*-The run of sockeye salmon into the Tuluksak River is small. Less than 150 fish passed the weir in any of the three years of operation. The only sockeye salmon escapement objective in the Kuskokwim River drainage is 3,000 for the Holitna River

(Francisco et al. 1992). Lake habitat that typically supports a large sockeye salmon population is not available in the Tuluksak River drainage.

*Coho salmon.*—The return of 8,328 coho salmon was larger than the 1992 run of 7,501 or the 1991 run of 4,565 (Harper 1995a; Harper 1995b). The weir was pulled from the river each year before completion of the run. Coho salmon may continue to pass the weir site until the end of September or later in small numbers. The decision to pull the weir was based upon the daily escapement falling below 1% of the cumulative passage.

#### *Migration Rates*

The migration time for salmon passing through the commercial or test fishery can play an important role in making in-season management decisions. Management can spread the harvest across several fishing periods to prevent the overharvest of individual stocks and allow adequate escapements.

Department tagging studies in 1961, 1962, and 1966 found that chum salmon swimming speeds averaged 19.5 km/d (range 5.4-76.8 km/d) in the Kuskokwim River (Francisco et al. 1992). Fish swimming at these rates would take between 2.2 and 31 days to reach the Tuluksak River weir from Bethel. The Refuge conducted a study in 1989 on chinook salmon and found swimming speeds averaged 13.5 km/d with a range of 0.41-54 km/d (Marino and Otis 1989).

The migration time using 50% cumulative passage at the test fishery and the weir falls within the range found by others. Swimming speed between the test fishery and the weir has varied for the period 1991-1993. For the three years chum salmon have averaged 13 km/d (9-16.9), chinook salmon 8.7 km/d (7.3-11.2) and coho salmon 7.5 km/d (6.5-9.3) km/d.

Chum salmon swimming at 13 km/d would pass through the lower Kuskokwim River commercial and subsistence fisheries in 17.5 days. A chinook salmon swimming 8.7 km/d would be vulnerable to harvest for approximately 25 days in the lower Kuskokwim River between the mouth and Tuluksak.

Estimated swimming speeds assume Tuluksak River fish are represented proportionally in test fishery samples. Tuluksak River fish could be on either side of the peak, increasing or decreasing the number of days to reach the weir. The 50% passage method, however, generally estimates lag times between the test fishery and the weir, if the cumulative proportion curves are similar in shape as they were in 1993. If accurate swimming speeds are needed, a tagging study should be conducted. Tagging data may determine spacial and temporal separation of chum and chinook salmon stocks in the lower Kuskokwim River.

Chinook and chum salmon passage at the weir were similar for the period of 1991 to 1993. The date that 50% of the cumulative population had passed the weir did not vary by more than 2 or 3 days for all three years (Figure 7, Appendix 5). The date that 50% of the coho salmon run passed by the weir, however, has varied by as much as 9 days.

The estimate of stream life above the weir appeared to be acceptable for 1993. Cumulative proportion curves for upstream passage of spawners and downstream passage of carcasses were similar in shape (Figure 5). If the cumulative proportion curves differ substantially, then several factors could be responsible. Nielson and Geen (1981), found residence time on redds to vary throughout the season. Early arriving salmon generally spend a longer period on the redd than late arrivals. Carcasses have other drawbacks including: rising water levels that wash fish downstream faster than normal, spawning distances above the weir, and carcasses sinking to the bottom above the weir before they are counted. Salmon carcasses, however, represented up to 1/3 of the upstream passage of salmon. A tagging study would provide more precise information on stream life above the weir.

#### *Aerial Survey Timing*

Salmon stream life is important in determining the optimal timing of aerial surveys to gather peak counts. Aerial surveys must account for stream life and run timing to provide useful data. Species, such as chum salmon, with short stream lives and protracted escapements should be surveyed more than once and the "Factor 5" or "Area Under the Curve" methods (Cousins et al. 1982) used to estimate total abundance. When 90% of the chum salmon had entered the river, over 60% of the carcasses had been passed downstream. Species with a long stream life and relatively short immigration time such as chinook salmon can be surveyed once, observing a large percentage of spawners. In the Tuluksak River by July 22, 1993, 90% of the chinook salmon had passed the weir, and 1% of the carcasses had been passed downstream. Surveys flown later would have had a higher percentage of carcasses to subtract from the live counts. A survey flown on July 30 would have over 96% of the weir counts minus 20% of the carcasses. The optimal time for conducting chinook salmon aerial surveys on the Tuluksak River falls within a narrow window of approximately 1 week at the end of July.

Run data from 1991-1993 suggest the optimal time to conduct aerial surveys for coho salmon would be the first week of September when 70% to 90% of the run have entered the river.

Funding, weather, and water conditions on the Tuluksak River, however, have made it impossible to conduct a single aerial survey for chum, chinook and coho salmon in some years. This emphasizes the need for a better method of estimating escapement.

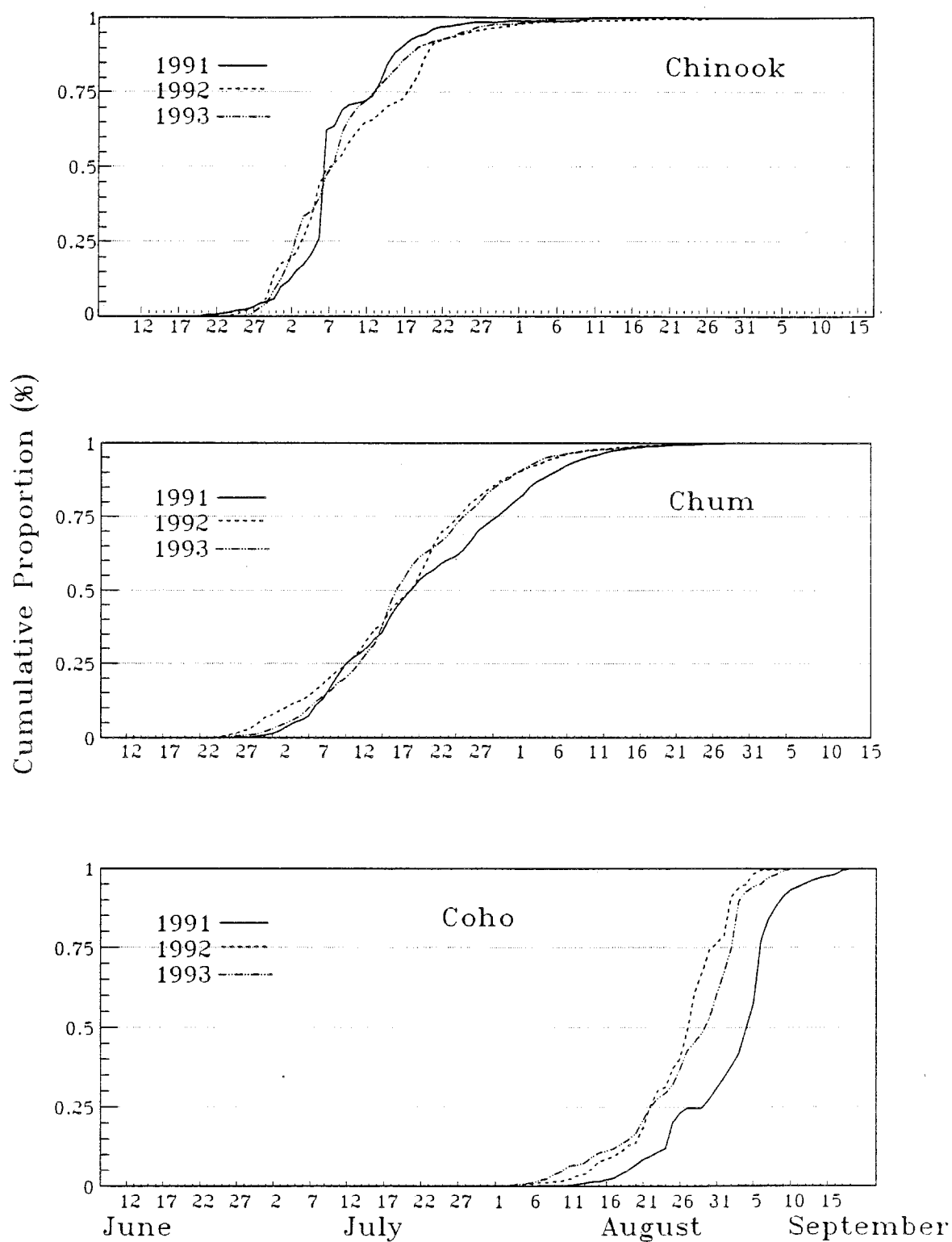


FIGURE 7.-Cumulative daily passage of chinook, chum, and coho salmon at the Tuluksak River weir, Alaska, 1991-1993.

### **Recommendations**

Based upon the data in this report and personal observations, the following is recommended:

1. Continue the weir operation for at least one full life cycle of chinook salmon. This data will determine if the low sex ratios for chinook salmon are cyclical.
2. Relocate the weir downstream to improve access during low water conditions.
3. A tagging study should be initiated in the lower Kuskokwim River to gather additional information on salmon migration rates. Data may indicate temporal or spacial separation of various stocks and estimate swimming speeds. Some information on temporal and spacial characteristics may be gathered by use of Genetic Stock Identification techniques.
4. Initiate a subsistence study in the village of Tuluksak to determine if the proportion of females in the harvest is significantly different from female passage at the weir. If a significantly higher proportion of females is being harvested, then an information and education effort should be started in the village. The goal is to maintain sufficient numbers of female chinook salmon in the spawning escapement while sustaining the overall harvest level of the village. This may be accomplished by selectively harvesting male chinook salmon.
5. Spawning habitat and carrying capacity data should be collected for chum, chinook, and coho salmon.
6. Aerial index surveys for chinook salmon should be conducted the last week of July. Aerial surveys for chum salmon, however, should be conducted a minimum of three times to collect the escapement information needed to estimate escapements.



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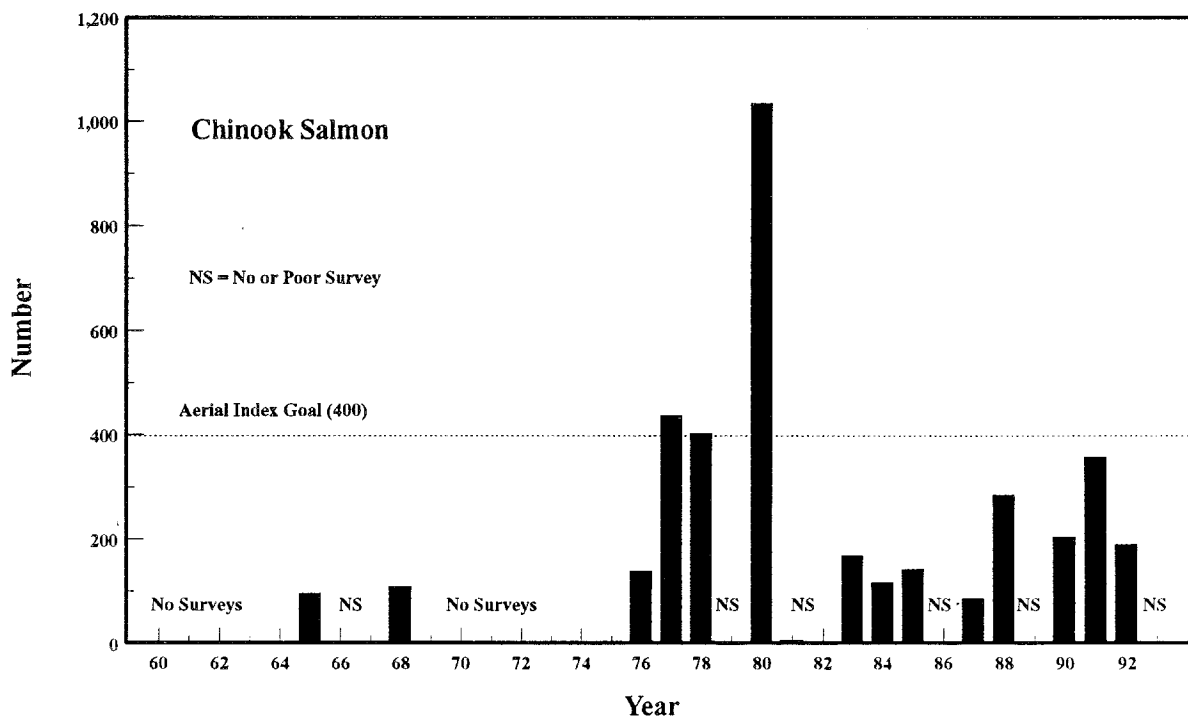
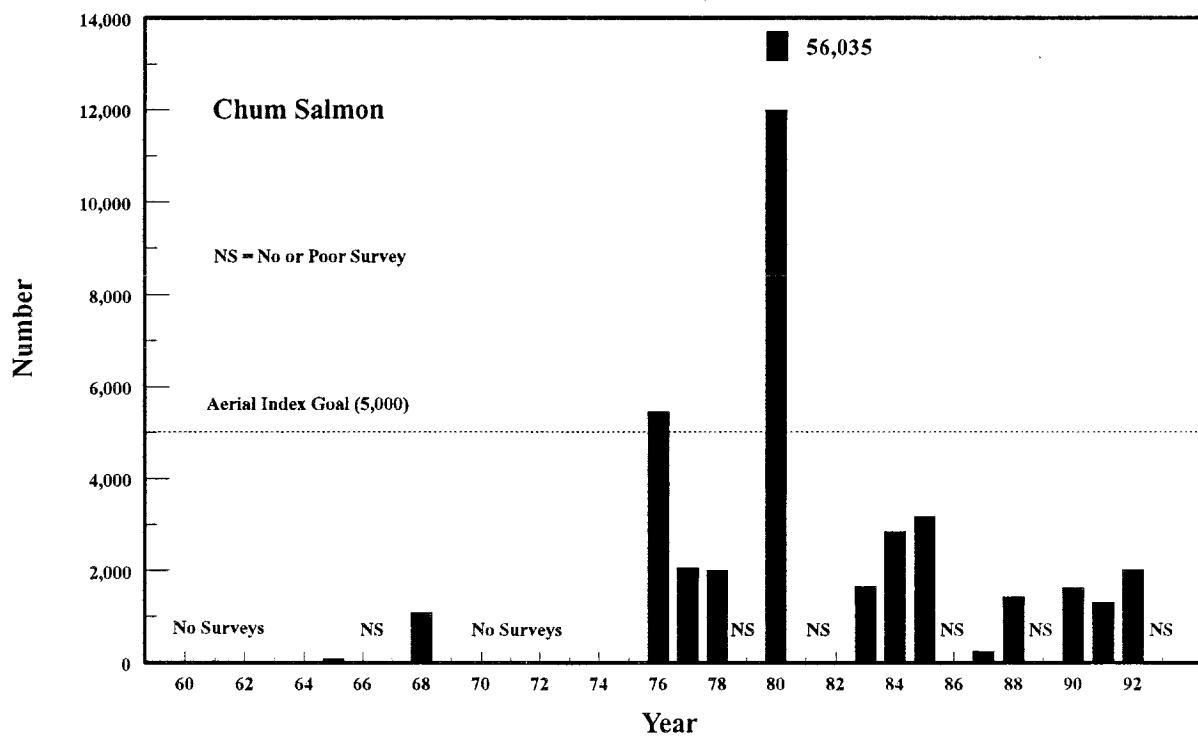
I thank personnel from the Yukon Delta National Wildlife Refuge for their assistance and support during the field season. I thank Doug Molyneaux, Alaska Department of Fish and Game (Commercial Fish Division, Bethel Office) for pressing and aging of salmon scales, technical assistance with compiling data forms and returning the data summary of ages.

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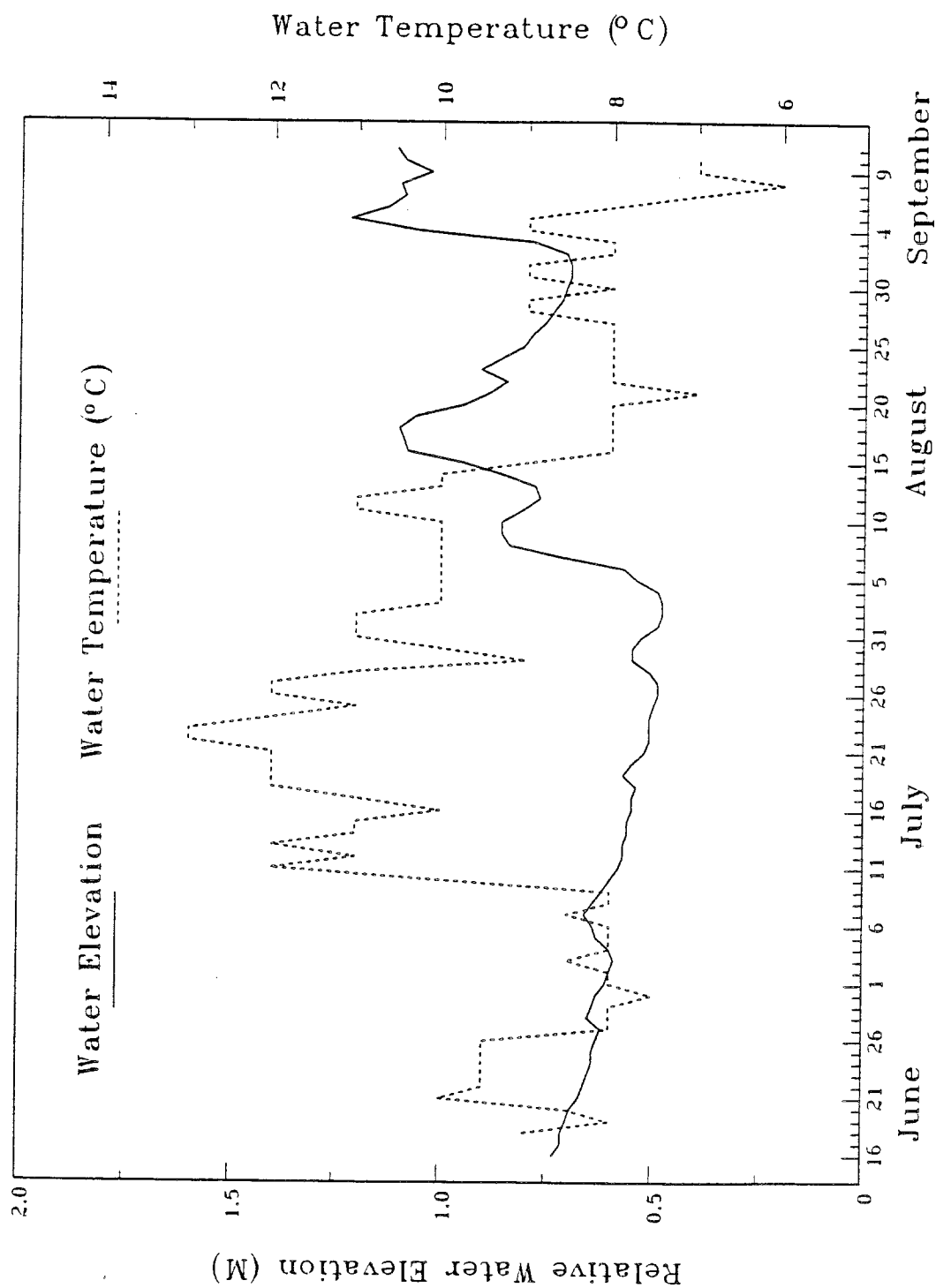
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Appendix 1.-Aerial index surveys for chinook and chum salmon in the Tuluksak River, Alaska, 1960-1993.



Appendix 2.—Relative water elevation and temperatures in the Tuluksak River, Alaska, 1993.

Appendix 3. Total daily weir counts of salmon, gill net marked salmon, and resident fish species, Tuluksak River, Alaska, 1993.

DATE	Gill Net Marked																Dolly Varden	Whitefish	Arctic Grayling	Northern Pike												
	Chum		Chinook		Pink		Sockeye		Coho		Chum		Chinook		Pink						Sockeye		Coho									
	Salmon		Salmon		Salmon		Salmon		Salmon		Salmon		Salmon		Salmon						Salmon		Salmon									
06/18	1		0		0		0		0		0		0		0		0		0		1		0		0		0		2			
06/19	1		0		0		0		0		0		0		0		0		0		0		0		0		2		0			
06/20	0		0		0		0		0		0		0		0		0		0		0		0		2		1		3		0	
06/21	10		0		0		0		0		0		0		0		0		0		0		2		1		0		0		0	
06/22	2		1		0		0		0		0		0		1		0		0		0		1		0		0		0		0	
06/23	1		0		0		0		0		0		0		0		0		0		0		1		1		0		0		0	
06/24	7		0		0		0		0		1		0		0		0		0		0		0		0		0		0		0	
06/25	18		1		0		0		0		1		0		1		0		0		0		1		0		0		0		0	
06/26	17		0		0		0		0		0		0		0		0		0		0		1		0		0		0		0	
06/27	22		2		0		0		0		2		0		0		0		0		0		0		0		0		0		0	
06/28	42		1		0		0		0		1		0		1		0		0		0		1		0		0		0		0	
06/29	26		0		0		0		0		2		0		0		0		0		0		2		0		0		0		0	
06/30	37		14		0		0		0		1		1		1		0		0		0		3		0		0		0		0	
07/01	101		40		0		0		0		1		5		0		0		0		0		0		7		0		0		0	
07/02	146		35		0		0		0		7		1		0		0		0		0		0		6		0		0		0	
07/03	119		102		0		0		0		3		2		0		0		0		0		0		12		0		0		0	
07/04	154		84		0		0		0		3		5		0		0		0		0		0		8		0		0		0	
07/05	149		120		0		0		0		0		5		0		0		0		0		0		8		0		0		0	
07/06	205		187		0		0		0		2		8		0		0		0		0		0		17		0		1		0	
07/07	313		157		0		0		0		4		9		0		0		0		0		0		19		0		0		0	
07/08	312		37		0		0		0		0		1		0		0		0		0		0		16		0		0		0	
07/09	242		93		0		0		0		4		2		0		0		0		0		0		33		5		0		1	
07/10	255		171		0		0		0		2		3		0		0		0		0		0		70		3		2		0	
07/11	379		100		0		4		0		6		2		0		0		0		0		0		10		0		0		0	
07/12	215		215		0		2		0		8		9		0		0		0		0		0		44		0		3		0	
07/13	341		107		3		2		0		6		2		0		0		0		0		0		11		0		0		0	
07/14	467		80		1		4		0		8		2		0		0		0		0		0		13		0		1		0	
07/15	413		43		0		1		0		8		1		0		0		0		0		0		13		1		0		0	
07/16	402		58		1		1		0		2		2		0		0		0		0		0		8		0		0		0	
07/17	816		63		5		4		0		9		0		0		1		0		0		1		31		0		0		0	
07/18	1010		60		3		3		0		6		5		0		0		0		0		0		4		1		0		0	
07/19	745		64		2		5		0		9		0		0		0		0		0		0		9		1		0		0	
07/20	534		61		3		7		0		5		5		0		0		0		0		0		4		1		1		0	
07/21	563		47		4		8		0		8		1		0		0		0		0		0		14		6		4		1	
07/22	377		54		3		0		0		10		3		0		0		0		0		0		11		1		2		0	
07/23	250		18		1		2		3		4		1		0		0		0		0		0		2		0		3		0	
07/24	243		23		3		7		1		1		0		0		0		0		0		0		1		0		0		0	
07/25	255		10		3		0		1		4		0		0		0		0		0		0		1		0		1		0	
07/26	324		15		9		3		0		4		0		0		0		0		0		0		5		9		1		0	
07/27	451		24		9		2		1		4		1		0		0		0		0		0		2		0		0		0	
07/28	387		24		4		1		1		4		0		0		0		0		0		0		1		0		0		0	
07/29	301		14		5		6		7		1		0		0		0		0		0		0		3		2		1		0	
07/30	322		21		8		2		3		0		2		0		0		0		0		0		4		5		7		0	
07/31	387		10		18		4		2		4		0		0		0		0		0		0		4		2		3		0	

Appendix 3--(Continued).

DATE	Gill Net Marked																Arctic Grayling	Northern Pike	
	Chum		Chinook		Pink		Sockeye		Chum		Chinook		Pink		Sockeye				
	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon	Salmon			
08/01	334	10	6	5	4	3	0	0	0	0	0	0	0	0	0	1	0	0	0
08/02	248	2	7	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0
08/03	184	1	4	0	7	3	0	0	0	0	0	0	0	0	0	0	1	0	0
08/04	234	7	3	0	25	4	0	0	0	0	0	0	0	0	0	0	0	3	0
08/05	213	4	1	2	22	2	0	0	0	0	0	0	0	0	0	3	3	0	0
08/06	194	9	7	1	21	1	0	0	0	0	0	0	0	0	1	5	0	0	0
08/07	193	13	10	1	66	2	1	0	0	0	0	0	0	0	6	5	0	0	0
08/08	148	3	4	1	50	2	1	0	0	0	0	0	0	0	3	1	0	0	0
08/09	83	5	4	0	111	1	1	0	0	0	0	0	0	0	4	3	0	0	0
08/10	63	1	1	1	83	0	0	0	0	0	0	0	0	0	3	0	0	0	0
08/11	54	5	3	1	129	0	0	0	0	0	0	0	0	0	3	8	4	2	0
08/12	48	1	5	0	42	0	0	0	0	0	0	0	0	0	0	3	2	3	0
08/13	53	0	6	0	42	0	0	0	0	0	0	0	0	0	2	5	3	4	0
08/14	50	0	4	0	149	0	0	0	0	0	0	0	0	0	5	2	3	1	0
08/15	31	0	4	0	117	1	0	0	0	0	0	0	0	0	12	3	2	0	0
08/16	23	0	2	1	46	0	0	0	0	0	0	0	0	0	4	1	2	0	0
08/17	15	0	4	0	67	0	0	0	0	0	0	0	0	0	5	5	5	0	0
08/18	30	1	5	0	105	1	0	0	0	0	0	0	0	0	4	4	4	1	0
08/19	27	0	5	0	137	0	0	0	0	0	0	0	0	0	10	0	4	0	0
08/20	55	0	3	0	166	1	0	0	0	0	0	0	0	0	6	3	7	0	0
08/21	26	0	8	0	358	2	0	0	0	0	0	0	0	0	5	10	5	0	0
08/22	9	0	2	0	342	1	0	0	0	0	0	0	0	0	21	8	18	1	0
08/23	16	0	8	0	199	1	0	0	0	0	0	0	0	0	3	2	16	0	0
08/24	9	0	1	0	143	0	0	0	0	0	0	0	0	0	14	4	9	0	0
08/25	22	0	4	0	211	0	0	0	0	0	0	0	0	0	14	5	25	2	0
08/26	24	0	3	0	396	0	0	0	0	0	0	0	0	0	13	1	36	2	0
08/27	19	0	2	1	504	0	0	0	0	0	0	0	0	0	30	3	37	1	0
08/28	8	0	2	1	221	0	0	0	0	0	0	0	0	0	5	0	24	0	0
08/29	6	0	1	0	227	0	0	0	0	0	0	0	0	0	15	1	27	1	0
08/30	3	0	2	0	406	1	0	0	0	0	0	0	0	0	32	0	64	1	0
08/31	2	0	1	0	617	0	0	0	0	0	0	0	0	0	36	0	25	2	0
09/01	6	0	0	0	545	0	0	0	0	0	0	0	0	0	25	0	37	0	0
09/02	2	0	2	0	620	0	0	0	0	0	0	0	0	0	20	0	51	0	0
09/03	2	0	1	0	1274	0	0	0	0	0	0	0	0	0	46	6	89	3	0
09/04	1	0	0	0	247	0	0	0	0	0	0	0	0	0	19	1	20	2	0
09/05	2	0	0	0	134	0	0	0	0	0	0	0	0	0	6	0	18	0	0
09/06	0	0	0	0	70	0	0	0	0	0	0	0	0	0	1	0	8	0	0
09/07	2	0	0	0	171	0	0	0	0	0	0	0	0	0	11	1	7	0	0
09/08	1	0	0	0	70	0	0	0	0	0	0	0	0	0	5	0	11	0	0
09/09	1	0	0	0	90	0	0	0	0	0	0	0	0	0	2	0	16	0	0
09/10	1	0	0	0	71	0	0	0	0	0	0	0	0	0	3	0	13	0	0
TOTAL	13804	2218	210	83	8328	172	84	1	1	385	502	642	75	5					



Appendix 4 - Daily weir counts of salmon in the Tuluksak River weir, Alaska, 1991-1993.

Date	Chum Salmon		Chinook Salmon		Pink Salmon		Sockeye Salmon		Coho Salmon	
	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992
06/12	0		0		0		0		0	
06/13	0		0		0		0		0	
06/14	0		0		0		0		0	
06/15	0		0		0		0		0	
06/16	0		0		0		0		0	
06/17	0		0		0		0		0	
06/18	0		0		0		0		0	
06/19	1		0		0		0		0	
06/20	0		0		0		0		0	
06/21	0		0		0		0		0	
06/22	0		0		0		0		0	
06/23	1		1		0		0		0	
06/24	0		3		0		0		0	
06/25	0		0		0		0		0	
06/26	3		1		0		0		0	
06/27	6		3		0		0		0	
06/28	2		4		2		0		0	
06/29	11		26		1		0		0	
06/30	20		37		6		0		0	
07/01	23		101		8		0		0	
07/02	50		146		6		0		0	
07/03	64		119		22		0		0	
07/04	113		154		84		0		0	
07/05	97		149		13		0		0	
07/06	59		107		24		0		0	
07/07	115		158		15		0		0	
07/08	279		229		23		0		0	
07/09	161		228		37		0		0	
07/10	326		280		254		0		0	
07/11	296		241		8		0		0	
07/12	276		202		38		0		0	
07/13	169		254		12		0		0	
07/14	120		307		4		0		0	
07/15	169		418		5		0		0	
07/16	210		387		11		0		0	
07/17	158		174		32		0		0	
07/18	390		510		43		0		0	
07/19	298		318		27		0		0	
07/20	234		265		15		0		0	
07/21	219		260		14		0		0	
07/22	232		483		377		0		0	
07/23	154		559		250		0		0	
07/24	124		664		12		0		0	
07/25	155		430		255		0		0	
07/26	107		230		324		0		0	
07/27	94		263		451		0		0	
07/28	142		330		387		0		0	
07/29	260		313		301		0		0	
07/30	200		322		1		0		0	
07/31	158		387		0		0		0	

Appendix 4 (Continued)

	Chum Salmon			Chinook Salmon			Pink Salmon			Sockeye Salmon			Coho Salmon		
	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993
08/01	131	196	334	0	6	10	3	50	6	0	4	5	0	3	4
08/02	139	211	248	2	3	2	4	79	7	0	3	0	0	3	4
08/03	190	143	184	1	4	1	3	43	4	0	1	0	0	2	7
08/04	168	119	234	0	2	7	1	49	3	1	0	0	0	3	25
08/05	159	137	213	0	7	4	5	94	1	3	1	2	2	20	22
08/06	208	135	194	1	4	9	7	104	7	0	2	1	0	28	21
08/07	153	70	193	0	3	13	1	82	10	0	2	1	4	21	66
08/08	92	117	148	0	2	3	6	100	4	1	0	1	0	11	50
08/09	107	103	83	0	1	5	5	145	4	0	0	0	3	16	111
08/10	118	80	63	0	0	1	3	98	1	0	2	1	4	17	83
08/11	99	97	54	0	2	5	3	92	3	0	1	1	4	42	129
08/12	73	82	48	1	0	1	3	201	5	1	0	0	16	81	42
08/13	78	32	53	3	0	0	0	65	6	1	0	0	19	44	42
08/14	61	33	50	1	1	0	1	86	4	1	0	0	20	121	149
08/15	38	28	31	1	1	0	0	46	4	0	0	0	2	186	117
08/16	53	16	23	0	0	0	1	28	2	0	1	1	25	43	46
08/17	55	30	15	0	0	0	2	39	4	0	2	0	26	80	67
08/18	31	22	30	0	1	1	3	47	5	0	1	0	55	93	105
08/19	29	20	27	0	0	0	0	64	5	0	1	0	66	154	137
08/20	27	22	55	0	0	0	0	16	3	1	6	0	70	64	166
08/21	16	25	26	1	2	0	1	36	8	0	1	0	89	367	358
08/22	9	13	9	0	1	0	0	15	2	0	2	0	42	529	342
08/23	17	18	16	0	0	0	0	7	8	0	0	0	59	318	199
08/24	11	4	9	0	0	0	0	6	1	0	0	0	52	101	143
08/25	13	9	22	0	1	0	1	8	4	1	1	0	380	420	211
08/26	7	8	24	0	0	0	0	3	3	0	0	0	139	246	396
08/27	6	15	19	0	0	0	0	21	2	0	0	1	79	647	504
08/28	2	9	8	0	1	0	0	26	2	0	0	1	0	902	221
08/29	7	6	6	0	0	0	0	10	1	0	1	0	1	448	227
08/30	11	1	3	0	2	0	0	10	2	0	0	0	135	557	406
08/31	6	1	2	0	0	0	0	4	1	0	0	0	150	161	617
09/01	0	2	6	0	2	0	2	4	2	0	3	0	149	174	545
09/02	6	8	2	0	1	0	0	14	2	0	0	0	165	922	620
09/03	1	2	2	0	0	0	0	8	1	0	1	0	193	199	1274
09/04	4	0	1	0	0	0	0	5	0	0	1	0	356	105	247
09/05	2	3	2	0	0	0	0	7	0	0	0	0	389	236	134
09/06	1	2	0	0	0	0	0	7	0	0	1	0	898	84	70
09/07	0	1	2	0	0	0	0	1	0	0	0	0	312	18	171
09/08	0	1	1	0	0	0	0	3	0	0	0	0	180	1	70
09/09	0	2	1	0	0	0	0	2	0	0	0	0	157	8	90
09/10	0	0	1	0	0	0	3	1	0	1	0	0	98	16	71
09/11	0	0	0	0	0	0	0	0	0	0	0	0	40	40	40
09/12	0	0	0	0	0	0	1	1	0	0	0	0	59	59	59
09/13	1	1	0	0	0	0	1	1	0	0	0	0	45	45	45
09/14	0	0	0	0	0	0	0	0	0	0	0	0	35	35	35
09/15	0	0	0	0	0	0	0	0	0	0	0	0	20	20	20
09/16	0	0	0	0	0	0	0	0	0	1	1	0	29	29	29
09/17	0	0	0	0	0	0	0	0	0	0	0	0	59	59	59
09/18	0	0	0	0	0	0	1	1	0	0	0	0	24	24	24
	76/5	11183	13804	697	1083	2218	392	2470	210	34	129	88	4651	7501	8328

Appendix 5 - Daily counts of salmon spawnouts and carcasses on the upstream side of the Tuluksak River weir, Alaska, 1991-1993.

Date	Chum Salmon			Chinook Salmon			Pink Salmon			Sockeye Salmon			Coho Salmon		
	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993
06/12															
06/13															
06/14															
06/15															
06/16			0			0			0			0			0
06/17			0			0			0			0			0
06/18			0			0			0			0			0
06/19			0			0			0			0			0
06/20			0			0			0			0			0
06/21			0			0			0			0			0
06/22			0			0			0			0			0
06/23			0			0			0			0			0
06/24			1			0			0			0			0
06/25		1	0			0			0			0			0
06/26		0	1			0			0			0			0
06/27		1	0			0			0			0			0
06/28		0	2			0			0			0			0
06/29		0	0			0			0			0			0
06/30		0	1			0			0			0			0
07/01		2	3			0			0			0			0
07/02		0	1			0			0			0			0
07/03		2	5			0			0			0			0
07/04		4	1			0			0			0			0
07/05	0	5	3			0			0			0			0
07/06	0	5	5			0			0			0			0
07/07	0	10	3			0			0			0			0
07/08	0	6	7			0			0			0			0
07/09	0	35	8			0			0			0			0
07/10	2	28	8			0			0			0			0
07/11	0	34	19			0			0			0			0
07/12	8	30	20			0			0			0			0
07/13	5	59	39			0			0			0			0
07/14	10	50	28			0			0			0			0
07/15	9	44	45			0			0			0			0
07/16	15	44	46			1			0			0			0
07/17	30	26	58			1			0			0			0
07/18	50	69	96			1			0			0			0
07/19	46	36	89			0			0			0			0
07/20	49	39	119			0			0			0			0
07/21	48	30	127			0			0			0			0
07/22	57	111	181			1			0			0			0
07/23	53	86	167			0			1			0			0
07/24	73	125	205			0			0			0			0
07/25	81	194	191			0			2			0			0
07/26	93	203	179			1			4			0			0
07/27	102	136	180			2			11			0			0
07/28	156	179	178			4			10			0			0
07/29	203	113	130			7			34			0			0
07/30	215	141	135			15			20			0			0
07/31	152	126	137			7			24			2			0

Appendix 5.-(Continued)

Date	Chum Salmon			Chinook Salmon			Pink Salmon			Sockeye Salmon			Coho Salmon		
	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993
08/01	183	109	151	25	24	29	61	20	1	0	0	0	0	0	0
08/02	151	104	133	13	25	30	60	20	5	0	0	0	0	0	0
08/03	157	124	122	11	19	17	56	33	5	0	0	1	0	0	0
08/04	128	112	170	13	21	26	31	23	4	0	0	0	0	0	0
08/05	239	108	114	21	19	39	70	32	3	0	0	0	0	0	0
08/06	173	105	174	9	17	43	52	34	6	0	2	0	0	0	0
08/07	172	108	223	9	13	29	35	38	9	2	1	0	0	0	0
08/08	163	99	133	10	22	35	16	49	7	0	2	0	0	0	0
08/09	223	85	160	6	11	27	28	40	12	0	0	0	0	0	0
08/10	232	82	138	3	5	26	27	48	11	0	1	0	0	0	0
08/11	166	98	107	1	5	24	14	54	3	0	0	2	0	0	0
08/12	105	96	84	2	7	18	17	55	3	0	3	0	0	0	0
08/13	109	87	67	1	5	14	16	28	2	0	0	1	0	0	0
08/14	87	67	73	0	3	18	8	41	5	2	2	0	0	0	0
08/15	51	66	70	1	1	12	5	51	1	0	1	0	0	0	0
08/16	66	65	62	1	1	3	8	60	5	2	1	1	0	0	0
08/17	65	51	44	0	2	4	9	72	2	1	0	1	0	0	0
08/18	52	54	36	0	0	6	4	79	5	1	2	1	0	0	0
08/19	47	41	20	0	0	1	5	80	2	2	6	2	0	0	0
08/20	40	31	22	0	0	4	2	64	4	1	3	2	0	0	0
08/21	37	19	15	0	0	1	4	65	3	0	0	0	0	1	1
08/22	19	23	12	0	0	0	0	66	2	0	4	1	0	0	0
08/23	41	17	16	0	0	0	4	54	0	0	3	0	0	0	0
08/24	34	18	10	0	0	2	7	54	1	1	1	1	0	0	0
08/25	34	19	15	0	0	0	1	39	4	2	1	1	0	0	0
08/26	28	6	8	0	0	0	1	21	4	0	1	1	0	0	0
08/27	16	4	8	1	0	0	2	3	3	0	0	2	0	0	0
08/28	16	1	8	0	0	2	2	6	2	0	0	1	0	0	0
08/29	7	5	13	0	0	0	1	0	4	1	0	1	0	0	0
08/30	7	2	9	0	0	1	0	6	4	2	0	0	0	0	0
08/31	12	4	9	0	0	0	0	12	2	0	1	0	0	0	0
09/01	15	4	10	0	0	0	4	4	2	0	1	0	1	0	0
09/02	8	5	4	0	0	0	0	5	2	0	0	0	1	0	0
09/03	11	3	5	0	0	0	0	4	1	0	0	1	1	0	1
09/04	2	5	4	0	1	1	0	3	2	0	1	2	0	0	1
09/05	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0
09/06	5	0	4	0	0	0	0	0	0	0	0	0	0	0	0
09/07	4	0	4	0	0	1	0	0	0	0	0	0	0	0	0
09/08	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
09/09	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09/10	3	1	1	0	0	0	1	0	1	0	0	0	0	0	0
09/11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09/12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09/13	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
09/14	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
09/15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09/16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09/17	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09/18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4376	3801	4678	167	327	548	729	1373	140	17	38	27	4	4	2

Appendix 6.-Daily cumulative proportion of salmon counted through the Tutuksak River weir, Alaska, 1991-1993.

Date	Chum Salmon			Chinook Salmon			Pink Salmon			Sockeye Salmon			Coho Salmon		
	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993
06/12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/21	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/22	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/23	0.000	0.000	0.001	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/24	0.000	0.000	0.002	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/25	0.000	0.004	0.003	0.006	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
06/26	0.000	0.011	0.004	0.010	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/27	0.001	0.017	0.006	0.014	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/28	0.002	0.024	0.009	0.020	0.003	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/29	0.003	0.032	0.011	0.022	0.006	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06/30	0.006	0.047	0.013	0.030	0.016	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/01	0.009	0.069	0.021	0.042	0.030	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/02	0.015	0.078	0.031	0.050	0.041	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
07/03	0.024	0.091	0.040	0.059	0.061	0.088	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.000
07/04	0.038	0.104	0.051	0.099	0.139	0.126	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.000
07/05	0.051	0.117	0.062	0.118	0.176	0.180	0.000	0.001	0.000	0.000	0.000	0.011	0.000	0.000	0.000
07/06	0.059	0.127	0.077	0.152	0.188	0.265	0.003	0.001	0.000	0.000	0.000	0.011	0.000	0.000	0.000
07/07	0.074	0.141	0.099	0.174	0.214	0.335	0.003	0.002	0.000	0.000	0.000	0.011	0.000	0.000	0.000
07/08	0.110	0.161	0.122	0.207	0.265	0.352	0.003	0.002	0.000	0.000	0.000	0.011	0.000	0.000	0.000
07/09	0.131	0.182	0.139	0.260	0.331	0.394	0.005	0.003	0.000	0.000	0.000	0.011	0.000	0.000	0.000
07/10	0.173	0.207	0.158	0.624	0.439	0.471	0.013	0.004	0.000	0.000	0.016	0.057	0.000	0.000	0.000
07/11	0.212	0.228	0.185	0.636	0.488	0.516	0.015	0.005	0.000	0.029	0.023	0.102	0.000	0.000	0.000
07/12	0.248	0.247	0.201	0.690	0.511	0.613	0.028	0.006	0.000	0.088	0.023	0.125	0.000	0.000	0.000
07/13	0.270	0.269	0.226	0.707	0.540	0.661	0.031	0.008	0.014	0.088	0.023	0.148	0.000	0.000	0.000
07/14	0.286	0.297	0.259	0.713	0.584	0.697	0.036	0.009	0.019	0.088	0.039	0.193	0.000	0.000	0.000
07/15	0.308	0.334	0.289	0.720	0.619	0.717	0.041	0.011	0.019	0.088	0.039	0.205	0.000	0.000	0.000
07/16	0.335	0.369	0.319	0.736	0.648	0.743	0.046	0.015	0.024	0.088	0.070	0.216	0.000	0.000	0.000
07/17	0.356	0.384	0.378	0.782	0.656	0.771	0.059	0.016	0.048	0.118	0.078	0.261	0.000	0.000	0.000
07/18	0.406	0.430	0.451	0.844	0.678	0.798	0.196	0.030	0.062	0.265	0.085	0.295	0.000	0.000	0.000
07/19	0.445	0.458	0.505	0.882	0.703	0.827	0.362	0.038	0.071	0.294	0.101	0.352	0.000	0.000	0.000
07/20	0.476	0.482	0.543	0.904	0.714	0.855	0.513	0.042	0.086	0.382	0.116	0.432	0.000	0.000	0.000
07/21	0.504	0.505	0.584	0.924	0.729	0.876	0.584	0.050	0.105	0.441	0.132	0.523	0.000	0.000	0.000
07/22	0.534	0.548	0.612	0.938	0.765	0.900	0.684	0.057	0.119	0.471	0.171	0.523	0.000	0.000	0.000
07/23	0.555	0.598	0.630	0.943	0.808	0.908	0.712	0.065	0.124	0.471	0.326	0.545	0.000	0.000	0.000
07/24	0.571	0.658	0.647	0.960	0.870	0.919	0.730	0.092	0.138	0.471	0.496	0.625	0.000	0.000	0.000
07/25	0.591	0.696	0.666	0.967	0.910	0.923	0.750	0.117	0.152	0.529	0.558	0.625	0.000	0.000	0.001
07/26	0.605	0.717	0.689	0.968	0.922	0.930	0.773	0.135	0.195	0.529	0.581	0.659	0.000	0.000	0.001
07/27	0.617	0.740	0.722	0.974	0.930	0.941	0.791	0.158	0.238	0.529	0.589	0.692	0.000	0.000	0.001
07/28	0.636	0.770	0.750	0.977	0.937	0.952	0.793	0.176	0.257	0.529	0.636	0.693	0.000	0.001	0.001
07/29	0.669	0.798	0.772	0.983	0.944	0.958	0.809	0.209	0.281	0.618	0.667	0.761	0.000	0.001	0.002
07/30	0.702	0.816	0.795	0.984	0.952	0.968	0.839	0.250	0.319	0.647	0.698	0.784	0.000	0.001	0.002
07/31	0.723	0.837	0.823	0.984	0.957	0.972	0.844	0.301	0.405	0.647	0.705	0.830	0.000	0.001	0.002

Appendix 6 - (Continued).

Date	Chum Salmon			Chinook Salmon			Pink Salmon			Sockeye Salmon			Coho Salmon		
	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993
08/01	0.740	0.855	0.847	0.984	0.962	0.977	0.852	0.321	0.433	0.647	0.736	0.886	0.000	0.002	0.003
08/02	0.758	0.873	0.865	0.987	0.965	0.977	0.862	0.353	0.467	0.647	0.760	0.886	0.000	0.002	0.003
08/03	0.783	0.886	0.879	0.989	0.969	0.978	0.870	0.371	0.486	0.647	0.767	0.886	0.000	0.002	0.004
08/04	0.804	0.897	0.896	0.989	0.970	0.981	0.872	0.391	0.500	0.676	0.767	0.886	0.000	0.003	0.007
08/05	0.825	0.909	0.911	0.989	0.977	0.983	0.885	0.429	0.505	0.765	0.775	0.909	0.001	0.005	0.010
08/06	0.852	0.921	0.925	0.990	0.981	0.987	0.903	0.471	0.538	0.765	0.791	0.920	0.001	0.009	0.012
08/07	0.872	0.927	0.939	0.990	0.983	0.993	0.906	0.504	0.586	0.765	0.806	0.932	0.002	0.012	0.020
08/08	0.884	0.938	0.950	0.990	0.985	0.994	0.921	0.545	0.605	0.794	0.806	0.943	0.002	0.013	0.026
08/09	0.898	0.947	0.956	0.990	0.986	0.996	0.934	0.603	0.624	0.794	0.806	0.943	0.002	0.016	0.040
08/10	0.913	0.954	0.960	0.990	0.986	0.997	0.941	0.643	0.629	0.794	0.822	0.955	0.003	0.018	0.049
08/11	0.926	0.963	0.964	0.990	0.988	0.999	0.949	0.680	0.643	0.794	0.829	0.966	0.004	0.023	0.065
08/12	0.936	0.970	0.968	0.991	0.988	1.000	0.957	0.762	0.667	0.824	0.829	0.966	0.007	0.034	0.070
08/13	0.945	0.973	0.972	0.996	0.988	1.000	0.957	0.788	0.695	0.853	0.829	0.966	0.011	0.040	0.075
08/14	0.954	0.976	0.975	0.997	0.989	1.000	0.959	0.823	0.714	0.882	0.829	0.966	0.016	0.056	0.093
08/15	0.959	0.979	0.977	0.999	0.990	1.000	0.959	0.841	0.733	0.882	0.829	0.966	0.016	0.081	0.107
08/16	0.966	0.980	0.979	0.999	0.990	1.000	0.962	0.853	0.743	0.882	0.837	0.977	0.022	0.087	0.113
08/17	0.973	0.983	0.980	0.999	0.990	1.000	0.967	0.868	0.762	0.882	0.853	0.977	0.027	0.097	0.121
08/18	0.977	0.985	0.982	0.999	0.991	1.000	0.974	0.887	0.786	0.882	0.860	0.977	0.039	0.110	0.133
08/19	0.981	0.986	0.984	0.999	0.991	1.000	0.974	0.913	0.810	0.882	0.868	0.977	0.053	0.130	0.150
08/20	0.984	0.988	0.988	0.999	0.991	1.000	0.974	0.920	0.824	0.912	0.915	0.977	0.068	0.139	0.170
08/21	0.986	0.991	0.990	1.000	0.993	1.000	0.977	0.934	0.862	0.912	0.922	0.977	0.087	0.188	0.213
08/22	0.988	0.992	0.991	1.000	0.994	1.000	0.977	0.940	0.871	0.912	0.938	0.977	0.096	0.258	0.254
08/23	0.990	0.993	0.992	1.000	0.994	1.000	0.977	0.943	0.910	0.912	0.938	0.977	0.109	0.301	0.277
08/24	0.991	0.994	0.993	1.000	0.994	1.000	0.977	0.946	0.914	0.912	0.938	0.977	0.120	0.314	0.295
08/25	0.993	0.995	0.994	1.000	0.994	1.000	0.980	0.949	0.933	0.941	0.946	0.977	0.202	0.370	0.320
08/26	0.994	0.995	0.996	1.000	0.994	1.000	0.980	0.950	0.948	0.941	0.946	0.977	0.232	0.403	0.368
08/27	0.995	0.997	0.997	1.000	0.994	1.000	0.980	0.959	0.957	0.941	0.946	0.989	0.249	0.489	0.428
08/28	0.995	0.997	0.998	1.000	0.995	1.000	0.980	0.969	0.967	0.941	0.946	1.000	0.249	0.610	0.455
08/29	0.996	0.998	0.998	1.000	0.995	1.000	0.980	0.973	0.971	0.941	0.953	1.000	0.249	0.669	0.482
08/30	0.997	0.998	0.999	1.000	0.997	1.000	0.980	0.977	0.981	0.941	0.953	1.000	0.278	0.744	0.531
08/31	0.998	0.998	0.999	1.000	0.997	1.000	0.980	0.979	0.986	0.941	0.953	1.000	0.310	0.765	0.605
09/01	0.998	0.998	0.999	1.000	0.999	1.000	0.985	0.981	0.986	0.941	0.977	1.000	0.342	0.788	0.670
09/02	0.999	0.999	0.999	1.000	1.000	1.000	0.985	0.986	0.995	0.941	0.977	1.000	0.378	0.911	0.745
09/03	0.999	0.999	0.999	1.000	1.000	1.000	0.985	0.989	1.000	0.941	0.984	1.000	0.419	0.938	0.898
09/04	0.999	0.999	0.999	1.000	1.000	1.000	0.985	0.991	1.000	0.941	0.992	1.000	0.496	0.952	0.927
09/05	1.000	0.999	1.000	1.000	1.000	1.000	0.985	0.994	1.000	0.941	0.992	1.000	0.579	0.983	0.943
09/06	1.000	1.000	1.000	1.000	1.000	1.000	0.985	0.997	1.000	0.941	1.000	1.000	0.773	0.994	0.952
09/07	1.000	1.000	1.000	1.000	1.000	1.000	0.985	0.998	1.000	0.941	1.000	1.000	0.840	0.997	0.972
09/08	1.000	1.000	1.000	1.000	1.000	1.000	0.985	0.999	1.000	0.941	1.000	1.000	0.878	0.997	0.981
09/09	1.000	1.000	1.000	1.000	1.000	1.000	0.985	1.000	1.000	0.941	1.000	1.000	0.912	0.998	0.991
09/10	1.000	1.000	1.000	1.000	1.000	1.000	0.985	1.000	1.000	0.971	1.000	1.000	0.933	1.000	1.000
09/11	1.000	1.000	1.000	1.000	1.000	1.000	0.992	1.000	1.000	0.971	1.000	1.000	0.942	1.000	1.000
09/12	1.000	1.000	1.000	1.000	1.000	1.000	0.995	1.000	1.000	0.971	1.000	1.000	0.954	1.000	1.000
09/13	1.000	1.000	1.000	1.000	1.000	1.000	0.997	1.000	1.000	0.971	1.000	1.000	0.964	1.000	1.000
09/14	1.000	1.000	1.000	1.000	1.000	1.000	0.997	1.000	1.000	0.971	1.000	1.000	0.972	1.000	1.000
09/15	1.000	1.000	1.000	1.000	1.000	1.000	0.997	1.000	1.000	0.971	1.000	1.000	0.976	1.000	1.000
09/16	1.000	1.000	1.000	1.000	1.000	1.000	0.997	1.000	1.000	1.000	1.000	1.000	0.982	1.000	1.000
09/17	1.000	1.000	1.000	1.000	1.000	1.000	0.997	1.000	1.000	1.000	1.000	1.000	0.995	1.000	1.000
09/18	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Appendix 7.- Estimated age and sex composition of weekly chum salmon passage from the Tuluksak River, Alaska 1993, and test of age composition between sexes.

		Brood Year and Age Group				Total
		1990	1989	1988	1987	
		0.2	0.3	0.4	0.5	
Stratum Dates: WEEKS 25 - 26						
Sampling Dates: 6/17 - 26						
Sample Size: 51						
Female	Percent of Sample	0.0	2.0	17.6	3.9	23.5
	Number in Passage	0	1	10	2	13
Male	Percent of Sample	0.0	5.9	49.0	21.6	76.5
	Number in Passage	0	3	28	12	44
Total	Percent of Sample	0.0	7.8	66.7	25.5	100.0
	Number in Passage	0	4	38	15	57
	Standard Error	0	2	4	4	
Stratum Dates: WEEK 27						
Sampling Dates: 6/27 - 7/3						
Sample Size: 150						
Female	Percent of Sample	0.0	4.0	18.0	7.3	29.3
	Number in Passage	0	20	89	36	145
Male	Percent of Sample	0.0	8.0	48.0	14.7	70.7
	Number in Passage	0	39	237	72	348
Total	Percent of Sample	0.0	12.0	66.0	22.0	100.0
	Number in Passage	0	59	325	108	493
	Standard Error	0	13	19	17	
Stratum Dates: WEEK 28						
Sampling Dates: 7/4 - 10						
Sample Size: 154						
Female	Percent of Sample	0.0	11.0	22.1	5.2	38.3
	Number in Passage	0	180	360	85	624
Male	Percent of Sample	0.0	14.9	39.0	7.8	61.7
	Number in Passage	0	243	635	127	1,006
Total	Percent of Sample	0.0	26.0	61.0	13.0	100.0
	Number in Passage	0	423	995	212	1,630
	Standard Error	0	58	64	44	
Stratum Dates: WEEK 29						
Sampling Dates: 7/11 - 17						
Sample Size: 148						
Female	Percent of Sample	0.0	12.8	30.4	0.7	43.9
	Number in Passage	0	389	922	20	1,332
Male	Percent of Sample	0.0	14.2	36.5	5.4	56.1
	Number in Passage	0	430	1,107	164	1,701
Total	Percent of Sample	0.0	27.0	66.9	6.1	100.0
	Number in Passage	0	820	2,029	184	3,033
	Standard Error	0	111	118	60	

Appendix 7.-(Continued).

		Brood Year and Age Group				Total
		1990	1989	1988	1987	
		0.2	0.3	0.4	0.5	
Stratum Dates: WEEK 30						
Sampling Dates: 7/18 - 24						
Sample Size: 144						
Female	Percent of Sample	2.1	18.8	26.4	1.4	48.6
	Number in Passage	78	698	982	52	1,809
Male	Percent of Sample	0.0	16.0	33.3	2.1	51.4
	Number in Passage	0	594	1,241	78	1,913
Total	Percent of Sample	2.1	34.7	59.7	3.5	100.0
	Number in Passage	78	1,292	2,223	129	3,722
	Standard Error	44	148	153	57	
Stratum Dates: WEEK 31						
Sampling Dates: 7/25 - 31						
Sample Size: 146						
Female	Percent of Sample	1.4	24.7	24.7	1.4	52.1
	Number in Passage	33	598	598	33	1,263
Male	Percent of Sample	0.7	18.5	28.8	0.0	47.9
	Number in Passage	17	449	698	0	1,164
Total	Percent of Sample	2.1	43.2	53.4	1.4	100.0
	Number in Passage	50	1,047	1,297	33	2,427
	Standard Error	29	100	101	23	
Stratum Dates: WEEK 32						
Sampling Dates: 8/1 - 7						
Sample Size: 146						
Female	Percent of Sample	4.8	35.6	21.9	0.7	63.0
	Number in Passage	77	570	350	11	1,008
Male	Percent of Sample	0.7	18.5	17.1	0.7	37.0
	Number in Passage	11	296	274	11	592
Total	Percent of Sample	5.5	54.1	39.0	1.4	100.0
	Number in Passage	88	866	624	22	1,600
	Standard Error	30	66	65	16	
Stratum Dates: WEEK 33						
Sampling Dates: 8/8 - 14						
Sample Size: 146						
Female	Percent of Sample	5.5	54.8	24.0	0.7	85.0
	Number in Passage	27	273	120	3	424
Male	Percent of Sample	0.7	9.6	4.8	0.0	15.1
	Number in Passage	3	48	24	0	75
Total	Percent of Sample	6.2	64.4	28.8	0.7	100.1
	Number in Passage	31	321	144	3	499
	Standard Error	10	20	19	3	



Appendix 7.-(Continued).

		Brood Year and Age Group				Total
		1990	1989	1988	1987	
		0.2	0.3	0.4	0.5	
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Stratum Dates:	WEEK 34					
Sampling Dates:	8/15 - 21					
Sample Size:	47					
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Female	Percent of Sample	8.5	48.9	27.7	0.0	85.1
	Number in Passage	18	101	57	0	176
Male	Percent of Sample	0.0	8.5	6.4	0.0	14.9
	Number in Passage	0	18	13	0	31
Total	Percent of Sample	8.5	57.4	34.1	0.0	100.0
	Number in Passage	18	119	71	0	207
	Standard Error	9	15	14	0	
<hr/>						
Stratum Dates:	WEEKS 36 - 37					
Sampling Dates:	8/22 - 9/10					
Sample Size:	31					
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Female	Percent of Sample	12.9	45.2	35.5	0.0	93.5
	Number in Passage	18	61	48	0	127
Male	Percent of Sample	0.0	3.2	3.2	0.0	6.5
	Number in Passage	0	4	4	0	9
Total	Percent of Sample	12.9	48.4	38.7	0.0	100.0
	Number in Passage	18	66	53	0	136
	Standard Error	8	12	12	0	
<hr/>						
Stratum Dates:	Season					
Sampling Dates:	6/17-9/10					
Sample Size:	1,163					
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Female	Percent of Sample	1.8	21.0	25.6	1.8	50.1
	Number in Passage	250	2,892	3,537	243	6,923
Male	Percent of Sample	0.2	15.4	30.9	3.4	49.9
	Number in Passage	31	2,126	4,260	464	6,882
Total	Percent of Sample	2.0	36.4	56.5	5.1	100.0
	Number in Passage	281	5,018	7,798	707	13,804
	Standard Error	57	195	201	89	

Z-test statistic of age composition difference between sexes.

Proportion Male	a	0.036	0.418	0.511	0.035	100%
V(Proportion males)	b	7.43E-05	7.50E-04	9.70E-04	7.43E-05	
Proportion Female	a	0.005	0.309	0.619	0.067	100%
V(Proportion females)	b	8.68E-06	6.75E-04	1.09E-03	1.46E-04	
Z-test statistic		3.467	2.884	-2.383	-2.178	
P	c	0.0000001	0.0000039	0.0000739	0.0002158	

a Proportion within each sex by age.

b V= variance for proportions.

c P value. Z was significant at alpha =0.05 if P was less than Bonferroni adjustment level of 0.0125

Appendix 8.- Estimated age and sex composition of weekly chinook salmon passage from the Tuluksak River, Alaska 1993, and test of age composition between sexes.

		Brood Year and Age Group								Total
		1990	1989	1988		1987		1986		
		1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	
Stratum Dates: WEEKS 25 -27										
Sampling Dates: 6/17 - 7/3										
Sample Size: 138										
Female	Percent of Sample	0.0	3.6	0.7	0.0	13.1	0.0	0.0	0.0	17.5
	Number in Passage	0	7	1	0	26	0	0	0	34
Male	Percent of Sample	0.0	39.4	28.5	0.0	10.9	2.9	0.0	0.7	82.5
	Number in Passage	0	77	56	0	21	6	0	1	162
Total	Percent of Sample	0.0	43.1	29.2	0.0	24.1	2.9	0.0	0.7	100.0
	Number in Passage	0	84	57	0	47	6	0	1	196
	Standard Error	0	8	8	0	7	3	0	1	
Stratum Dates: WEEK 28										
Sampling Dates: 7/4 - 10										
Sample Size: 134										
Female	Percent of Sample	0.0	0.0	2.2	0.0	9.7	0.0	0.0	0.0	11.9
	Number in Passage	0	0	19	0	82	0	0	0	101
Male	Percent of Sample	0.7	43.3	34.3	1.5	5.2	1.5	0.7	0.7	88.1
	Number in Passage	6	367	291	13	44	13	6	6	748
Total	Percent of Sample	0.7	43.3	36.6	1.5	14.9	1.5	0.7	0.7	100.0
	Number in Passage	6	367	310	13	127	13	6	6	849
	Standard Error	6	36	35	9	26	9	6	6	
Stratum Dates: WEEK 29										
Sampling Dates: 7/11 - 17										
Sample Size: 134										
Female	Percent of Sample	0.0	0.7	2.2	0.0	7.5	0.0	1.5	0.0	11.9
	Number in Passage	0	5	15	0	50	0	10	0	80
Male	Percent of Sample	1.5	62.7	19.4	0.0	4.5	0.0	0.0	0.0	88.1
	Number in Passage	10	417	129	0	30	0	0	0	586
Total	Percent of Sample	1.5	63.4	21.6	0.0	11.9	0.0	1.5	0.0	100.0
	Number in Passage	10	422	144	0	80	0	10	0	666
	Standard Error	7	28	24	0	19	0	7	0	
Stratum Dates: WEEK 30										
Sampling Dates: 7/18 - 24										
Sample Size: 134										
Female	Percent of Sample	0.0	0.0	1.5	0.0	13.4	0.0	0.0	0.0	14.9
	Number in Passage	0	0	5	0	44	0	0	0	49
Male	Percent of Sample	3.0	56.0	21.6	0.0	4.5	0.0	0.0	0.0	85.1
	Number in Passage	10	183	71	0	15	0	0	0	278
Total	Percent of Sample	3.0	56.0	23.1	0.0	17.9	0.0	0.0	0.0	100.0
	Number in Passage	10	183	76	0	59	0	0	0	327
	Standard Error	5	14	12	0	11	0	0	0	
Stratum Dates: WEEKS 31 - 34										
Sampling Dates: 7/25 -8/18										
Sample Size: 79										
Female	Percent of Sample	0.0	0.0	3.8	0.0	17.7	0.0	2.5	0.0	24.1
	Number in Passage	0	0	7	0	32	0	5	0	43
Male	Percent of Sample	0.0	53.2	17.7	0.0	5.1	0.0	0.0	0.0	75.9
	Number in Passage	0	96	32	0	9	0	0	0	137
Total	Percent of Sample	0.0	53.2	21.5	0.0	22.8	0.0	2.5	0.0	100.0
	Number in Passage	0	96	39	0	41	0	5	0	180
	Standard Error	0	10	8	0	9	0	3	0	

Appendix 8.- (Continued).

		Brood Year and Age Group								
		1990	1989	1988	1987	1986			Total	
		1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	
Stratum Dates:		Season								
Sampling Dates:		7/25 -8/18								
Sample Size:		619								
Female	Percent of Sample	0.0	0.5	2.1	0.0	10.5	0.0	0.7	0.0	13.9
	Number in Passage	0	12	47	0	234	0	14	0	307
Male	Percent of Sample	1.2	51.4	26.1	0.6	5.4	0.8	0.3	0.4	86.1
	Number in Passage	26	1,141	579	13	119	18	6	8	1,911
Total	Percent of Sample	1.2	52.0	28.2	0.6	15.9	0.8	0.9	0.4	100.0
	Number in Passage	26	1,153	626	13	353	18	21	8	2,218
	Standard Error	11	50	46	9	36	9	10	6	

Z-Test of age composition difference between sexes.

Proportion Male	a	0.000	0.039	0.153	0.000	0.760	0.000	0.047	0.000	100%
V(Proportion males)	b	0.00E+00	3.75E-04	1.20E-03	0.00E+00	7.61E-03	0.00E+00	6.41E-04	0.00E+00	1.82E-02
Proportion Female	a	0.014	0.597	0.303	0.007	0.062	0.010	0.003	0.004	100%
V(Proportion females)	b	5.10E-05	1.05E-03	3.01E-04	2.00E-05	7.27E-05	2.01E-05	2.00E-05	2.00E-05	1.38E-03
z-test statistic		-1.908	-14.755	-3.868	-1.481	7.962	-2.148	1.705	-0.909	0.000
P	c	0.056	0.000	0.000	0.139	0.000	0.032	0.088	0.364	1.000

a Proportion within each sex.

b V= variance for proportions of each age within each sex.

c P value. Z was significant at alpha =0.05 if P was less than Bonferroni adjustment level of 0.006.

Appendix 9.-Estimated age and sex composition of sockeye salmon passage from the Tuluksak River, Alaska, 1993.

		Brood Year and Age Group					Total
		1990	1989		1988	1987	
		0.2	0.3	1.2	1.3	2.3	
Stratum Dates: WEEKS 28 - 35							
Sampling Dates: SEASON							
Sample Size: 33							
Female	Percent of Sample	0.0	6.1	9.1	27.3	6.1	48.5
	Number in Passage	0	5	8	24	5	43
Male	Percent of Sample	3.0	6.1	15.2	27.3	0.0	51.5
	Number in Passage	3	5	13	24	0	45
Total	Percent of Sample	3.0	12.1	24.2	54.5	6.1	100.0
	Number in Passage	3	11	21	48	5	88
	Standard Error	3	5	7	8	4	

Appendix 10.-Estimated age and sex composition of weekly coho salmon passage from the Tuluksak River, Alaska 1993, and test of age composition between sexes.

		Brood Year and Age Group					Total
		1990	1989	1988		1987	
		1.1	2.1	2.2	3.1	3.2	
Stratum Dates: WEEKS 30 - 32							
Sampling Dates: 7/23 -8/7							
Sample Size: 59							
Female	Proportion of sample	0.0	40.7	0.0	0.0	0.0	40.7
	Number in Passage	0	68	0	0	0	68
Male	Proportion of sample	0.0	55.9	0.0	3.4	0.0	59.3
	Number in Passage	0	94	0	6	0	100
Total	Percent of Sample	0.0	96.6	0.0	3.4	0.0	100.0
	Number in Passage	0	162	0	6	0	168
	Standard Error	0	4	0	4	0	
Stratum Dates: WEEK 33							
Sampling Dates: 8/8 - 14							
Sample Size: 119							
Female	Percent of Sample	0.0	21.0	0.0	0.0	0.0	21.0
	Number in Passage	0	127	0	0	0	127
Male	Percent of Sample	2.5	74.8	0.0	1.7	0.0	79.0
	Number in Passage	15	453	0	10	0	479
Total	Percent of Sample	2.5	95.8	0.0	1.7	0.0	100.0
	Number in Passage	15	581	0	10	0	606
	Standard Error	9	11	0	7	0	
Stratum Dates: WEEK 34							
Sampling Dates: 8/15 - 21							
Sample Size: 129							
Female	Percent of Sample	0.0	34.9	0.0	2.3	0.0	37.2
	Number in Passage	0	347	0	23	0	371
Male	Percent of Sample	2.3	58.9	0.0	1.6	0.0	62.8
	Number in Passage	23	587	0	15	0	625
Total	Percent of Sample	2.3	93.8	0.0	3.9	0.0	100.0
	Number in Passage	23	934	0	39	0	996
	Standard Error	13	21	0	17	0	
Stratum Dates: WEEK 35							
Sampling Dates: 8/22 - 28							
Sample Size: 119							
Female	Percent of Sample	0.9	25.5	12.7	0.9	0.9	40.9
	Number in Passage	18	513	257	18	18	825
Male	Percent of Sample	0.0	41.8	13.6	2.7	0.9	59.1
	Number in Passage	0	843	275	55	18	1,191
Total	Percent of Sample	0.9	67.3	26.4	3.6	1.8	100.0
	Number in Passage	18	1,356	531	73	37	2,016
	Standard Error	18	87	82	35	25	

Appendix 10.- (Continued).

		Brood Year and Age Group					
		1990	1989	1988		1987	
		1.1	2.1	2.2	3.1	3.2	Total
Stratum Dates:		WEEK 36					
Sampling Dates:		8/29 - 9/4					
Sample Size:		121					
Female	Percent of Sample	0.0	43.8	3.3	1.7	0.0	48.8
	Number in Passage	0	1,724	130	65	0	1,919
Male	Percent of Sample	0.0	40.5	4.1	6.6	0.0	51.2
	Number in Passage	0	1,594	163	260	0	2,017
Total	Percent of Sample	0.0	84.3	7.4	8.3	0.0	100.0
	Number in Passage	0	3,318	293	325	0	3,936
	Standard Error	0	131	94	99	0	
Stratum Dates:		WEEK 37					
Sampling Dates:		9/5 - 10					
Sample Size:		122					
Female	Percent of Sample	0.0	44.3	0.0	1.6	0.0	45.9
	Number in Passage	0	268	0	10	0	278
Male	Percent of Sample	0.8	48.4	0.0	4.9	0.0	54.1
	Number in Passage	5	293	0	30	0	328
Total	Percent of Sample	0.8	92.6	0.0	6.6	0.0	100.0
	Number in Passage	5	561	0	40	0	606
	Standard Error	5	14	0	14	0	
Stratum Dates:		Season					
Sampling Dates:		7/23 - 9/10					
Sample Size:		669					
Female	Percent of Passage	0.2	36.6	4.6	1.4	0.2	43.1
	Number in Passage	18	3,049	387	116	18	3,588
Male	Percent of Passage	0.5	46.4	5.3	4.5	0.2	56.9
	Number in Passage	43	3,864	438	376	18	4,740
Total	Percent of Passage	0.7	83.0	9.9	5.9	0.4	100.0
	Number in Passage	62	6,913	824	493	37	8,328
	Standard Error	24	160	125	107	25	

Z-test for age composition difference.

Proportion Male	a	0.005	0.850	0.108	0.032	0.005	100%
V(Proportion males)	b	2.4E-05	5.7E-03	6.6E-04	2.1E-04	2.4E-05	
Proportion Female	a	0.009	0.815	0.092	0.079	0.004	100%
V(Proportion females)	b	1.3E-05	3.20E-03	4.2E-04	4.2E-04	1.4E-05	
Z-test statistic		-0.669	0.364	0.470	-1.869	0.201	
P	c	0.063	0.128	0.102	0.001	0.177	

a Proportion within each sex by age.

b V= variance for proportions.

c P value. Z was significant at alpha =0.05 if P was less than Bonferroni adjustment level of 0.0125.